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**Yamazaki et al.**

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(54) **DATA PROCESSING APPARATUS AND METHOD, AND STORAGE MEDIUM**

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(51) **Int. Cl.**[7] ..... **G09G 5/02**; H04N 7/167; H04N 11/00; B42D 15/00

(52) **U.S. Cl.** ..... **345/629**; 345/630; 345/638; 345/641; 380/200; 283/72; 283/113; 348/460

(58) **Field of Search** ..... 382/233, 232, 382/248, 250, 251, 100; 380/200–203, 232, 241, 253, 277, 278–285; 283/72–75, 100–107, 113; 705/5, 51, 57–59; 348/460; 345/629, 630, 632, 638, 844, 555, 556, 639, 641

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(57) **ABSTRACT**

This invention provides a technique capable of always keeping digital watermark information embedded in image data having the embedded digital watermark information by an optimum scheme on the basis of a time factor, or removing a digital watermark, or erasing the image data. An apparatus for achieving the above object has functions of holding image data having additional information embedded as a digital watermark, detecting time information related to the image data, and changing the embedding scheme for the additional information as the digital watermark embedded in the image data on the basis of the detected time information.

**20 Claims, 17 Drawing Sheets**

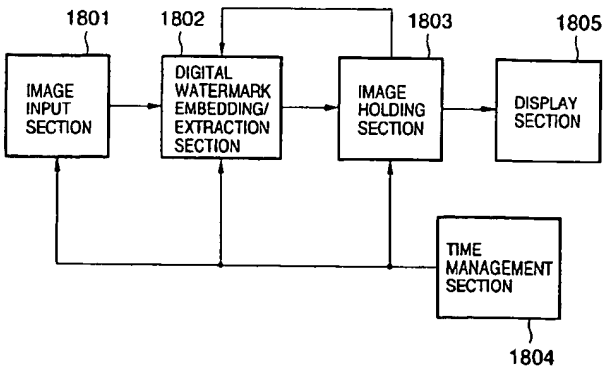

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FIG. 1

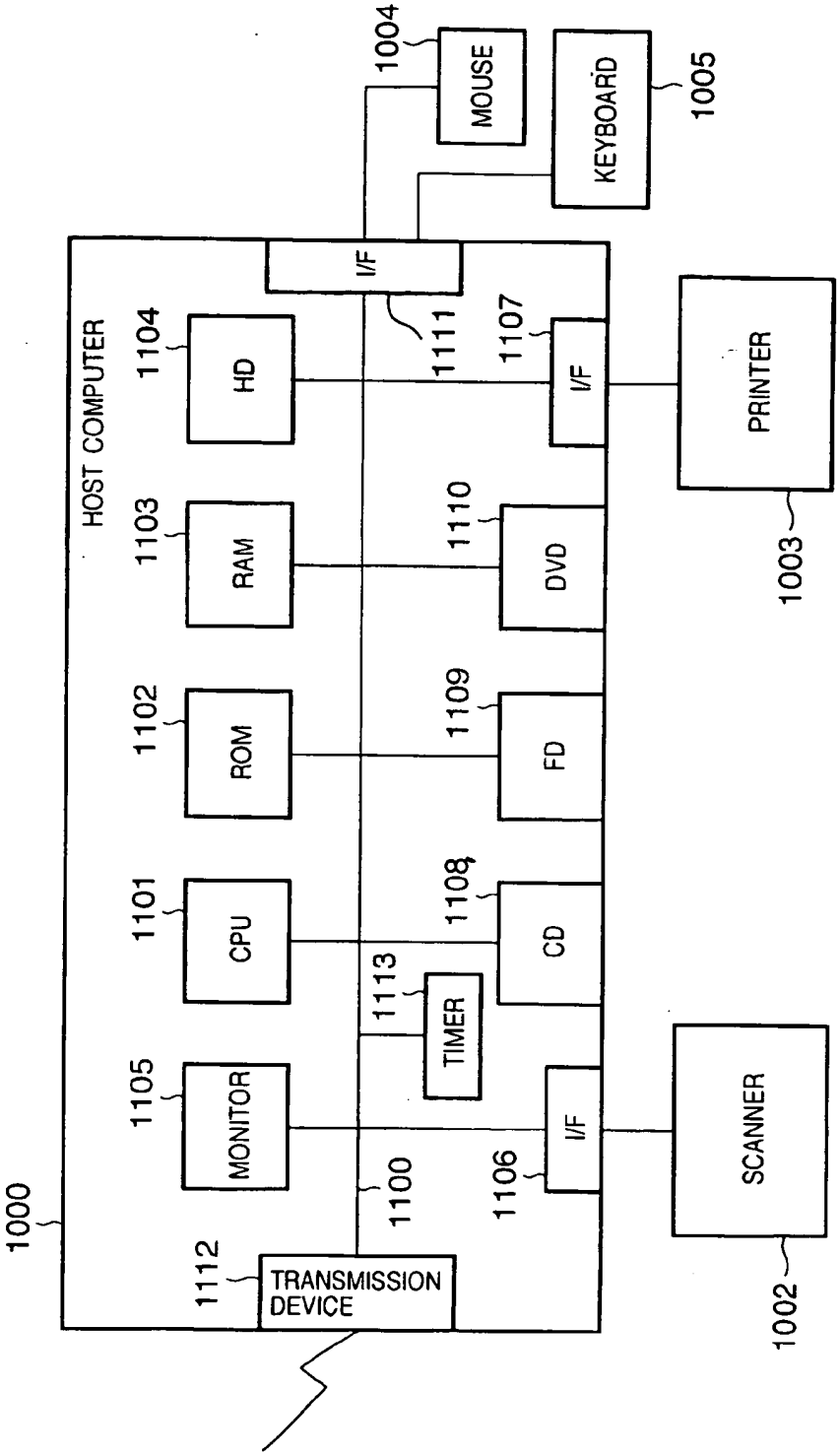

1004
MOUSE
KEYBOARD
1005
I/F
1111
1107
HOST COMPUTER
1104
HD
I/F
PRINTER
1003
1103
RAM
1110
DVD
1102
ROM
1109
FD
1101
CPU
1108
CD
1113
TIMER
1105
MONITOR
I/F
SCANNER
1002
1000
1100
1106
1112
TRANSMISSION DEVICE

FIG. 2

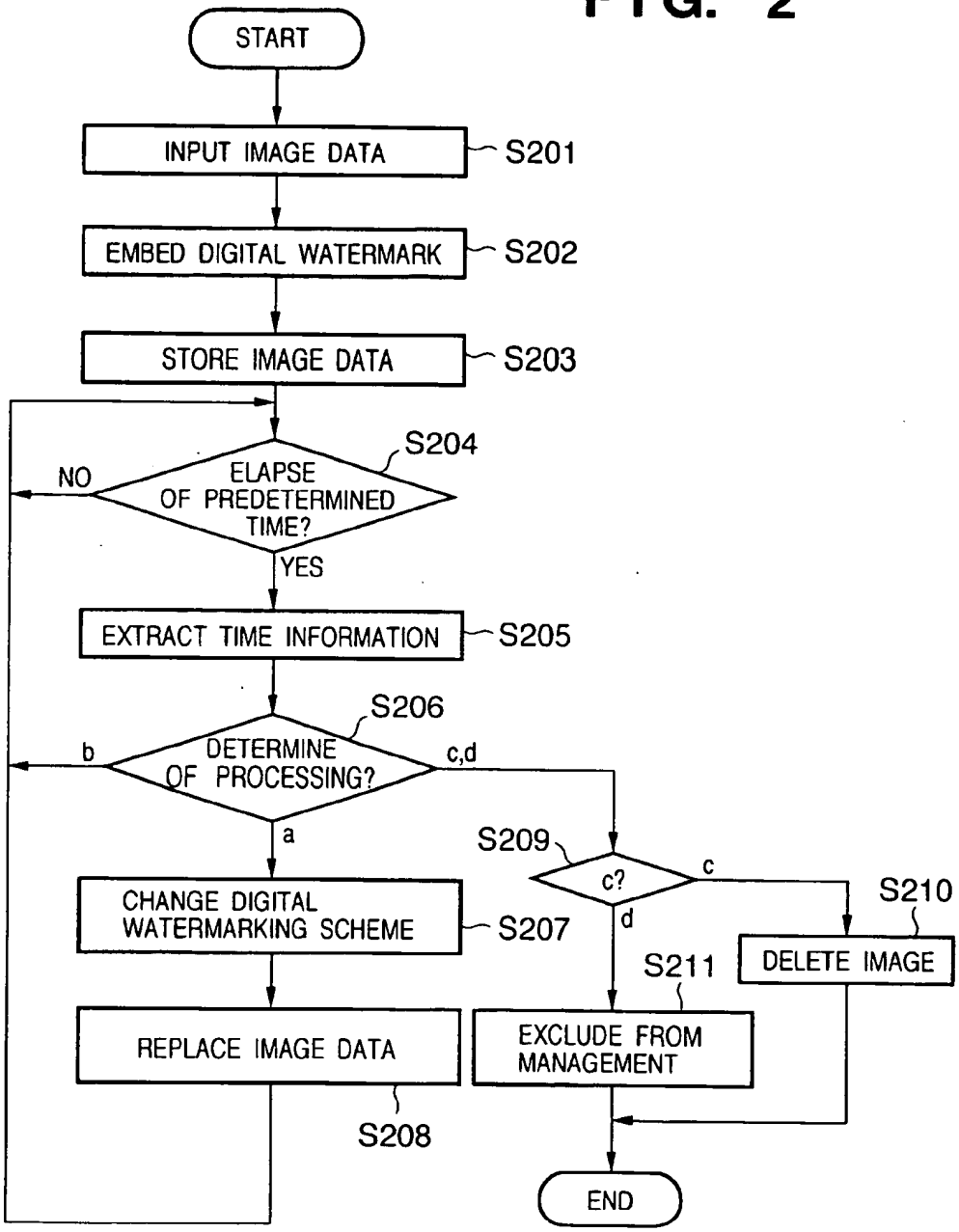

START
INPUT IMAGE DATA
S201
EMBED DIGITAL WATERMARK
S202
STORE IMAGE DATA
S203
S204
ELAPSE OF PREDETERMINED TIME?
NO
YES
EXTRACT TIME INFORMATION
S205
S206
DETERMINE OF PROCESSING?
b
c,d
a
S209
c?
c
d
S210
DELETE IMAGE
CHANGE DIGITAL WATERMARKING SCHEME
S207
S211
EXCLUDE FROM MANAGEMENT
REPLACE IMAGE DATA
S208
END

FIG. 3

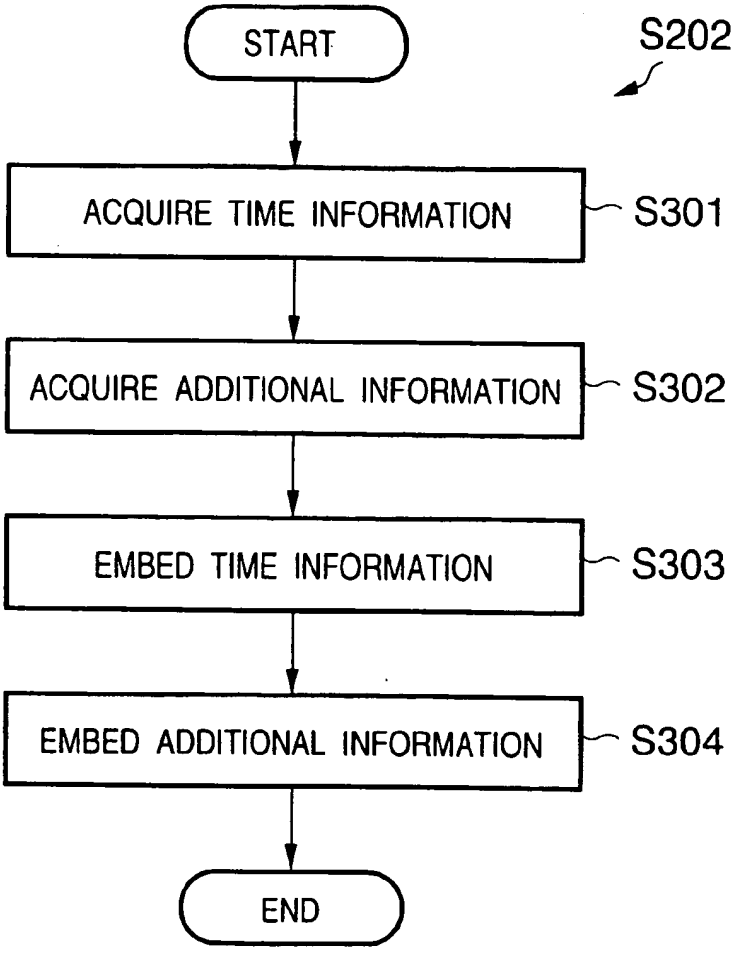

START
S202
ACQUIRE TIME INFORMATION
S301
ACQUIRE ADDITIONAL INFORMATION
S302
EMBED TIME INFORMATION
S303
EMBED ADDITIONAL INFORMATION
S304
END

FIG. 4

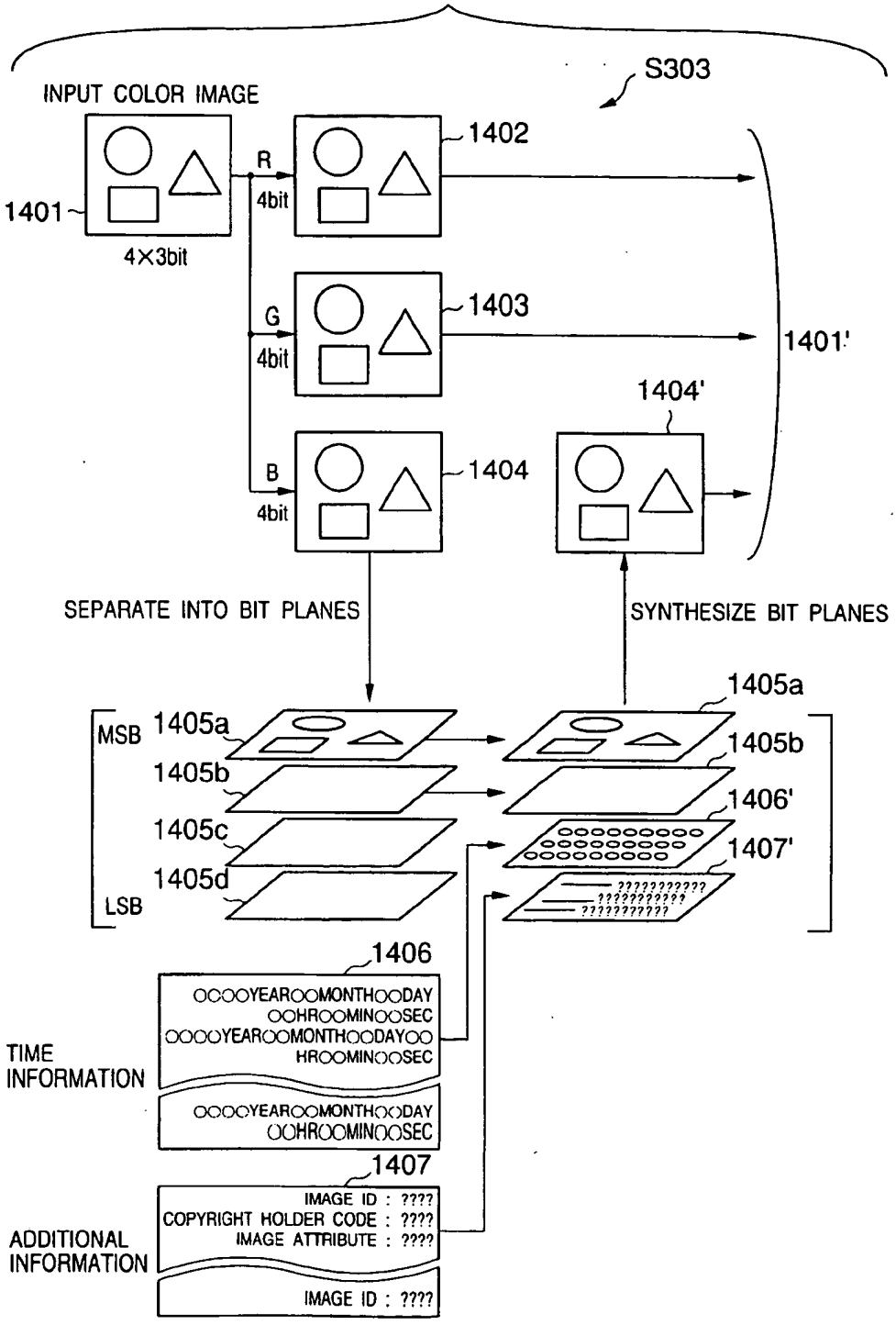
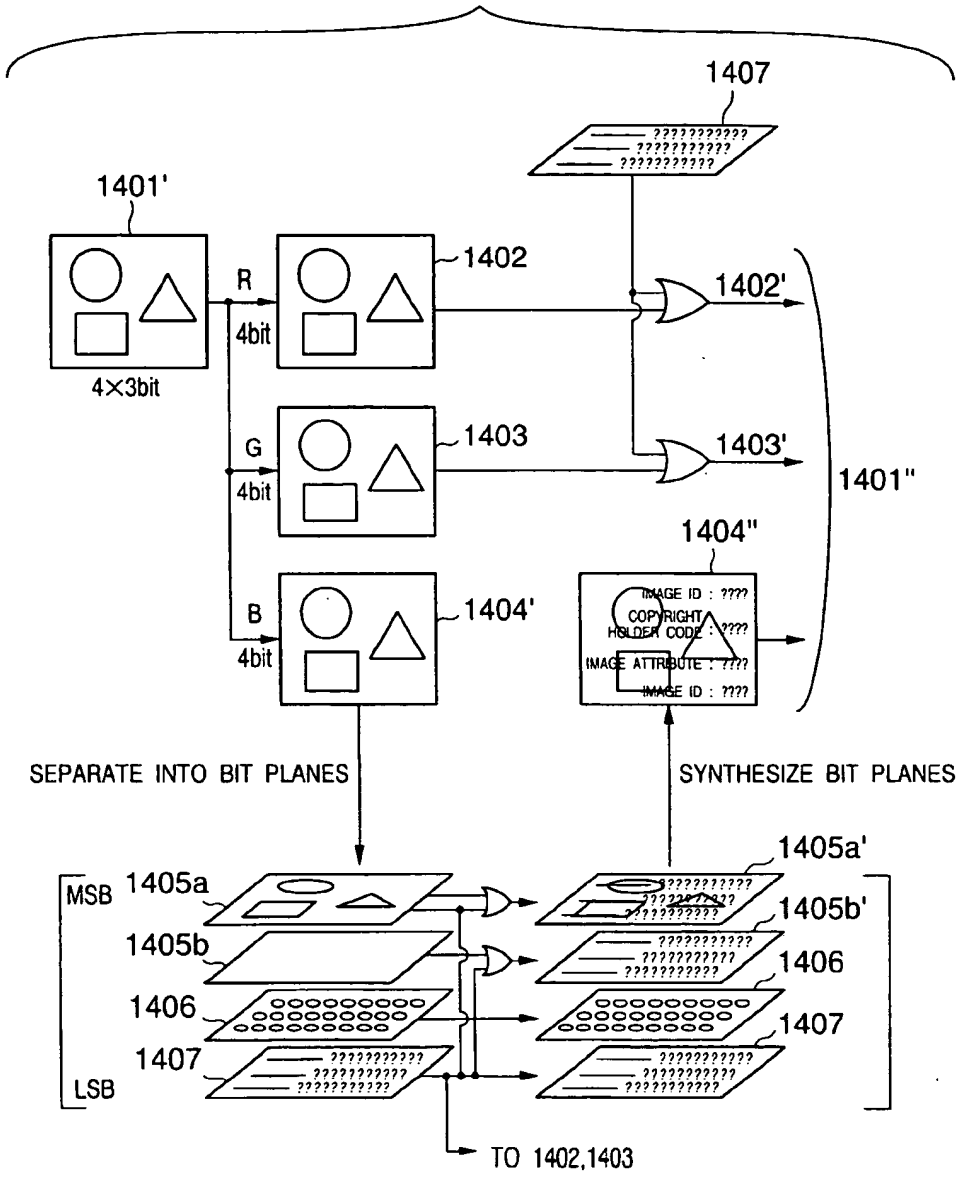

S303
INPUT COLOR IMAGE
1401
4×3bit
R
4bit
G
4bit
B
4bit
1402
1403
1404
1401'
1404'
SEPARATE INTO BIT PLANES
SYNTHESIZE BIT PLANES
MSB
LSB
1405a
1405b
1405c
1405d
1406'
1407'
1406
TIME INFORMATION
OOOOYEAROOMONTHOODAY
OOHROOMINOOSEC
OOOOYEAROOMONTHOODAYOO
HROOMINOOSEC
OOOOYEAROOMONTHOODAY
OOHROOMINOOSEC
1407
ADDITIONAL INFORMATION
IMAGE ID : ????
COPYRIGHT HOLDER CODE : ????
IMAGE ATTRIBUTE : ????
IMAGE ID : ????

FIG. 5




1406 : TIME INFORMATION
1407 : ADDITIONAL INFORMATION

FIG. 6

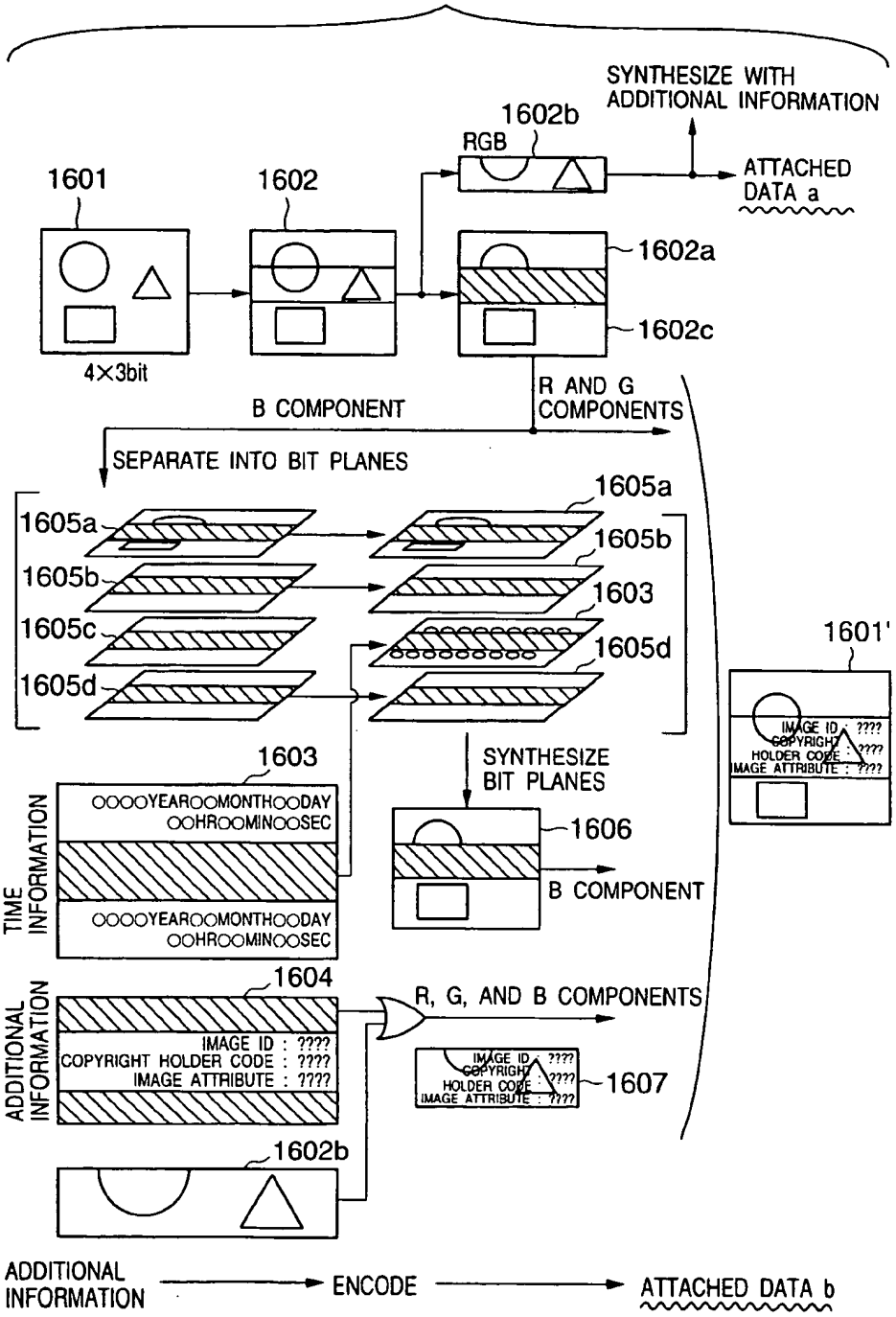

SYNTHESIZE WITH ADDITIONAL INFORMATION
1602b
RGB
ATTACHED DATA a
1601
1602
1602a
1602c
4×3bit
B COMPONENT
R AND G COMPONENTS
SEPARATE INTO BIT PLANES
1605a
1605b
1605c
1605d
1603
1601'
IMAGE ID : ????
COPYRIGHT HOLDER CODE : ????
IMAGE ATTRIBUTE : ????
SYNTHESIZE BIT PLANES
1606
B COMPONENT
TIME INFORMATION
OOOOYEAROOMONTHOODAY
OOHROOMINOOSEC
1604
ADDITIONAL INFORMATION
R, G, AND B COMPONENTS
1607
ADDITIONAL INFORMATION
ENCODE
ATTACHED DATA b

FIG. 7

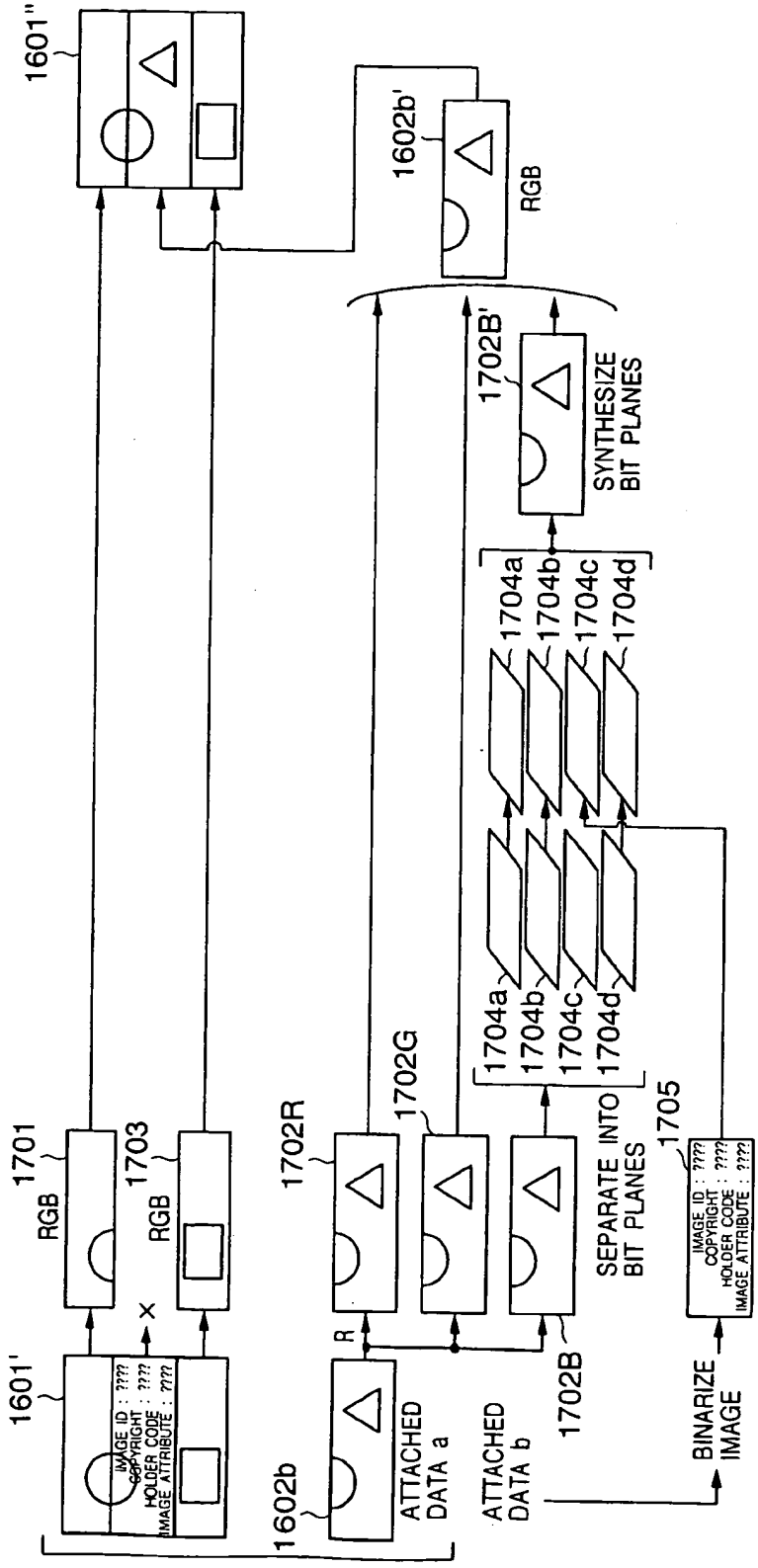

1601"
1602b'
RGB
1702B'
SYNTHESIZE BIT PLANES
1704a
1704b
1704c
1704d
1704a
1704b
1704c
1704d
1701
RGB
1703
RGB
1702R
1702G
SEPARATE INTO BIT PLANES
1705
1601'
IMAGE ID : ????
COPYRIGHT : ????
HOLDER CODE : ????
IMAGE ATTRIBUTE : ????
R
1702B
1602b
ATTACHED DATA a
ATTACHED DATA b
BINARIZE IMAGE

FIG. 8

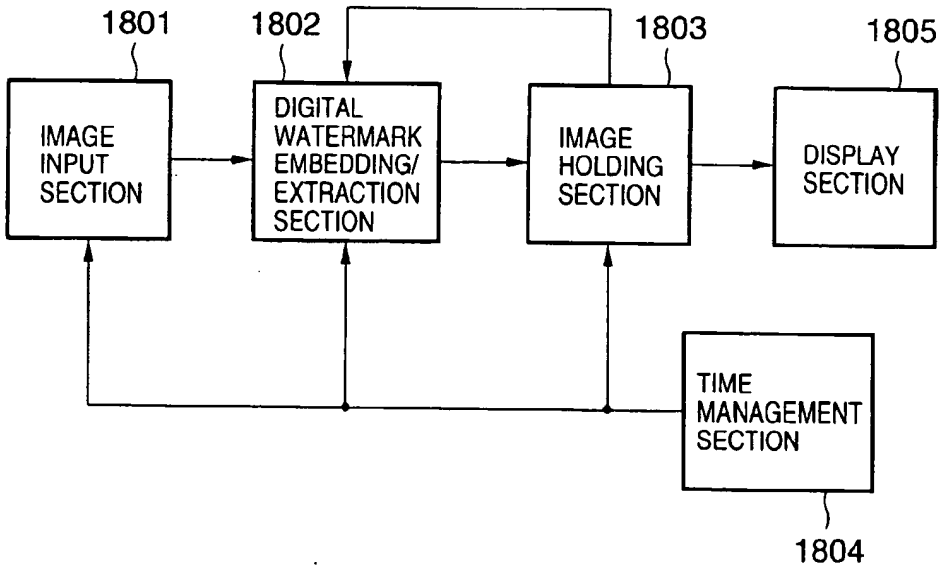

1801
1802
1803
1805
IMAGE INPUT SECTION
DIGITAL WATERMARK EMBEDDING/ EXTRACTION SECTION
IMAGE HOLDING SECTION
DISPLAY SECTION
TIME MANAGEMENT SECTION
1804

FIG. 9

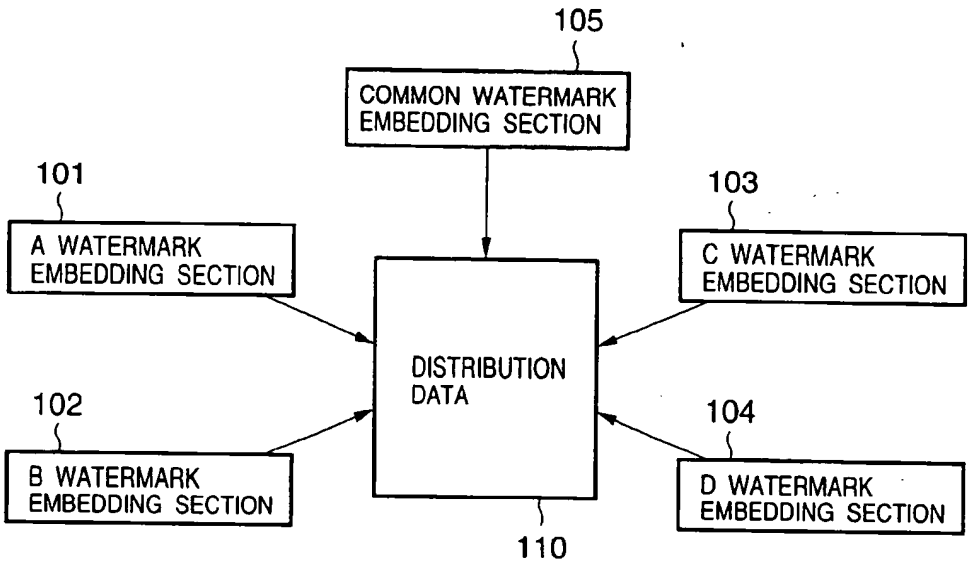

105
COMMON WATERMARK EMBEDDING SECTION
101
A WATERMARK EMBEDDING SECTION
103
C WATERMARK EMBEDDING SECTION
DISTRIBUTION DATA
102
B WATERMARK EMBEDDING SECTION
104
D WATERMARK EMBEDDING SECTION
110

FIG. 10A

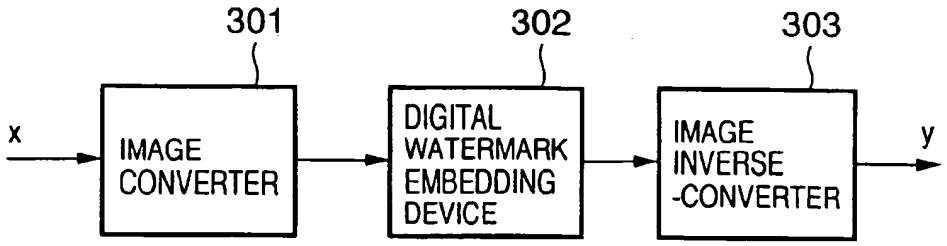



FIG. 10B

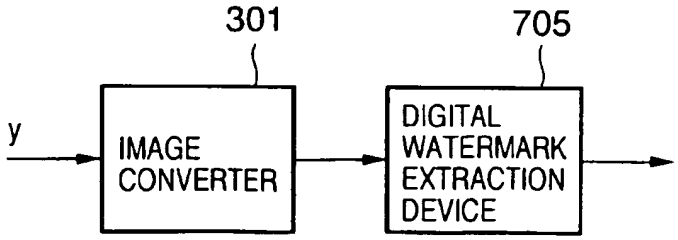


FIG. 11

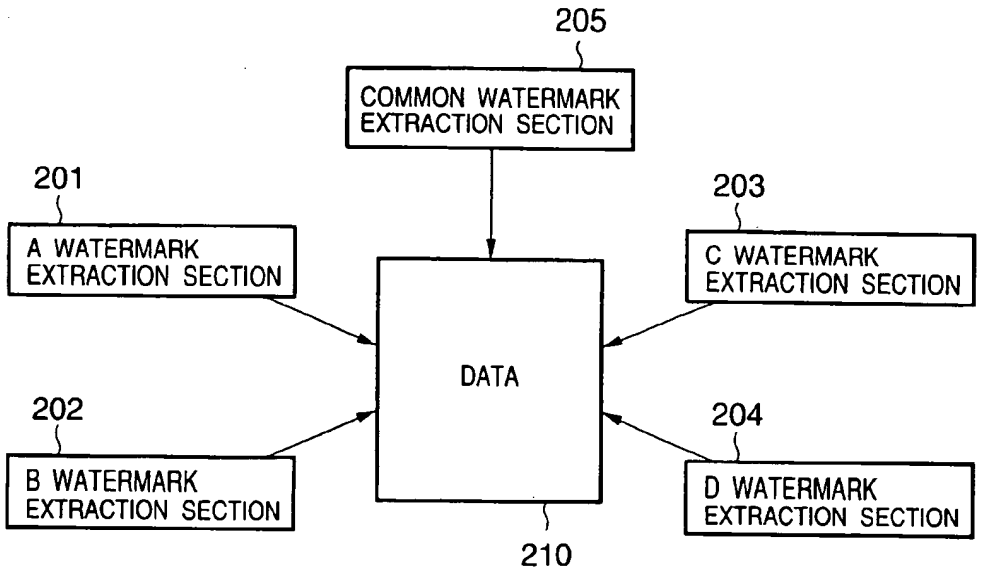

205
COMMON WATERMARK EXTRACTION SECTION
201
A WATERMARK EXTRACTION SECTION
203
C WATERMARK EXTRACTION SECTION
DATA
202
B WATERMARK EXTRACTION SECTION
204
D WATERMARK EXTRACTION SECTION
210

FIG. 12

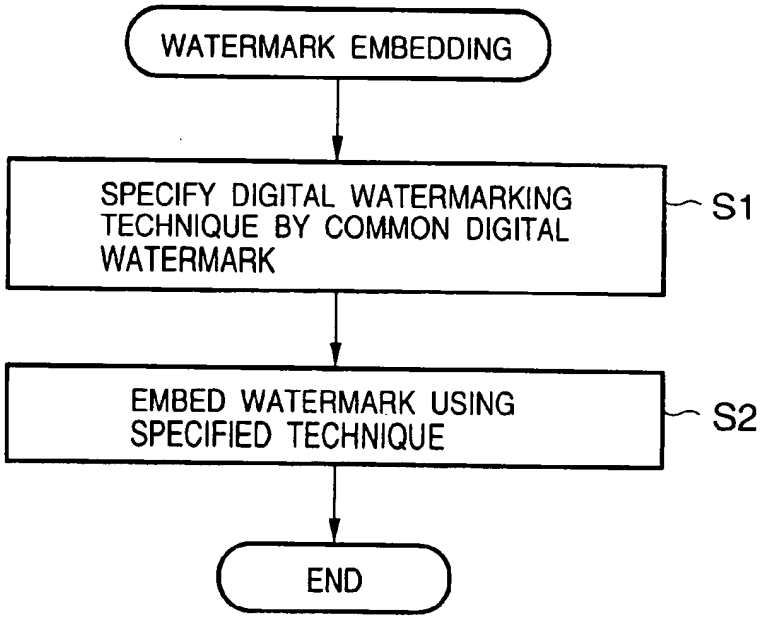

WATERMARK EMBEDDING
SPECIFY DIGITAL WATERMARKING TECHNIQUE BY COMMON DIGITAL WATERMARK
S1
EMBED WATERMARK USING SPECIFIED TECHNIQUE
S2
END

FIG. 13

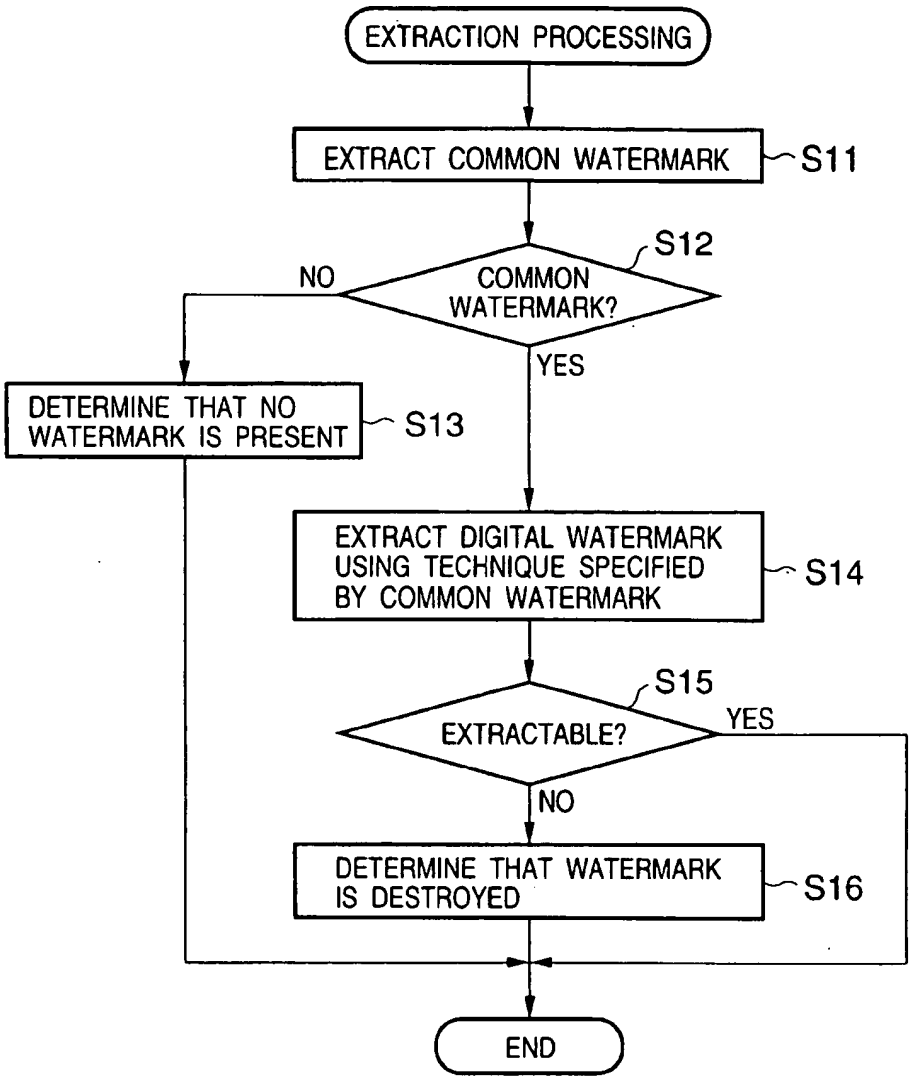

EXTRACTION PROCESSING
EXTRACT COMMON WATERMARK
S11
S12
COMMON WATERMARK?
NO
YES
DETERMINE THAT NO WATERMARK IS PRESENT
S13
EXTRACT DIGITAL WATERMARK USING TECHNIQUE SPECIFIED BY COMMON WATERMARK
S14
S15
EXTRACTABLE?
YES
NO
DETERMINE THAT WATERMARK IS DESTROYED
S16
END

FIG. 14

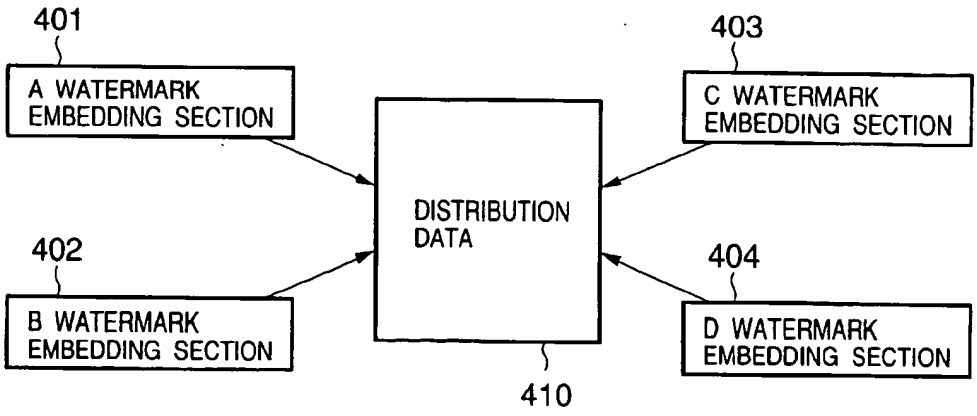

401
A WATERMARK EMBEDDING SECTION
402
B WATERMARK EMBEDDING SECTION
DISTRIBUTION DATA
410
403
C WATERMARK EMBEDDING SECTION
404
D WATERMARK EMBEDDING SECTION

FIG. 15

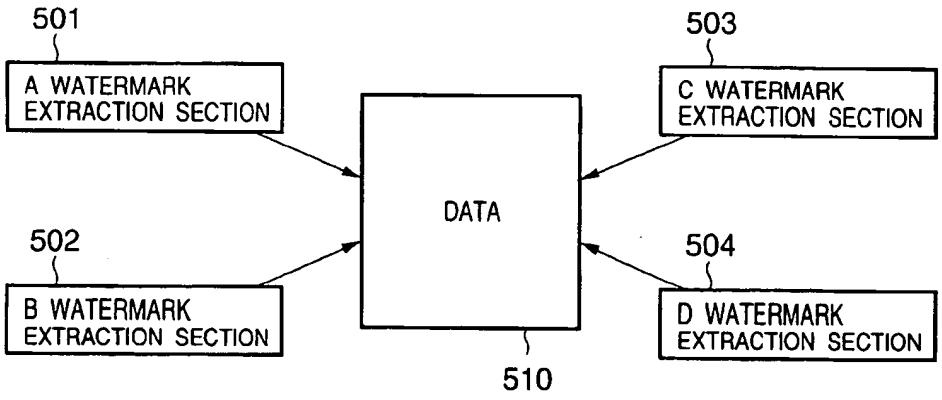

501
A WATERMARK EXTRACTION SECTION
503
C WATERMARK EXTRACTION SECTION
DATA
502
B WATERMARK EXTRACTION SECTION
504
D WATERMARK EXTRACTION SECTION
510

FIG. 16

601
602
1111

FIG. 17

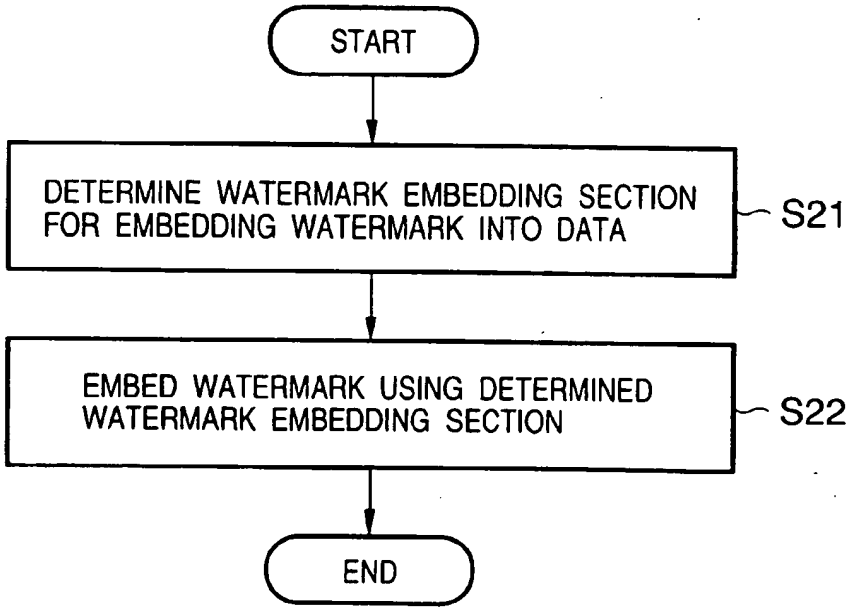
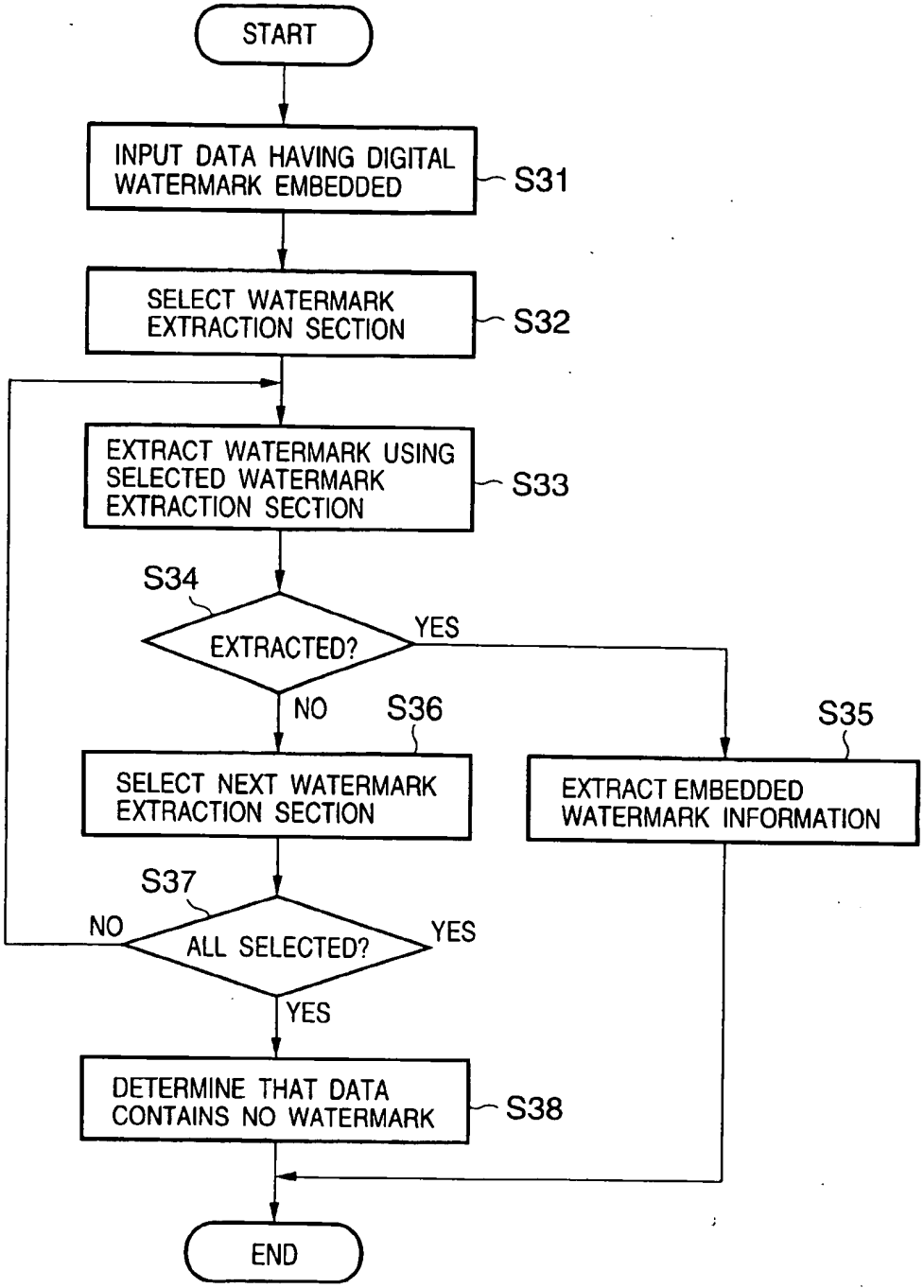

START
DETERMINE WATERMARK EMBEDDING SECTION FOR EMBEDDING WATERMARK INTO DATA
S21
EMBED WATERMARK USING DETERMINED WATERMARK EMBEDDING SECTION
S22
END

FIG. 18


START
INPUT DATA HAVING DIGITAL WATERMARK EMBEDDED
S31
SELECT WATERMARK EXTRACTION SECTION
S32
EXTRACT WATERMARK USING SELECTED WATERMARK EXTRACTION SECTION
S33
S34
EXTRACTED?
YES
NO
S36
S35
SELECT NEXT WATERMARK EXTRACTION SECTION
EXTRACT EMBEDDED WATERMARK INFORMATION
S37
NO
ALL SELECTED?
YES
YES
DETERMINE THAT DATA CONTAINS NO WATERMARK
S38
END

# DATA PROCESSING APPARATUS AND METHOD, AND STORAGE MEDIUM

## FIELD OF THE INVENTION

The present invention relates to a method and apparatus for managing digital watermark information to be embedded into digital data of an image or audio, and a storage medium which stores a program for executing the method.

## BACKGROUND OF THE INVENTION

Recent development of computers and networks is remarkable, and various kinds of information such as text data, image data, and audio data are processed in a computer or network. Since such data is digital data, copy data with the same quality can be easily obtained. To protect the copyright for such data, copyright information or user information is often embedded into image data or audio data as a digital watermark. The digital watermark is a technique of executing predetermined processing for image data or audio data to secretly embed another information into the data.

When watermark information is extracted from data having a digital watermark embedded therein, the copyright information, user information, and identification information of the data can be obtained. In addition, an illicit copy can be traced using such an digital watermark.

As the first condition required for such a digital watermark, a watermark is embedded such that the embedded information is imperceptible, i.e., degradation in quality of original digital information is suppressed (quality). As the second condition, the watermark information embedded in digital information continues to remain, i.e., the embedded watermark information is not lost even by editing processing such as data compression or filtering or an attack such as alteration (resiliency). As the third condition, the amount of watermark information to be embedded can be selected in accordance with the application purpose (information amount). These conditions required for a digital watermark generally have tradeoff relationships. For example, when a highly resilient digital watermark is realized, degradation in quality becomes relatively large, or the embeddable watermark information amount becomes small in many cases.

For, e.g., a multilevel still image, the digital watermark embedding methods can be roughly classified into a scheme of embedding a watermark in the space domain and a scheme of embedding a watermark in the frequency domain. Various methods to be described below are known.

As the former scheme of embedding a digital watermark in the space domain by patchwork, an IBM scheme (W. Bender, D. Gruhl, & N. Morimoto, Techniques for Data Hiding, "Proceedings of the SPIE", San Jose Calif., USA, February 1995) and G. B. Rhoads & W. Linn; "Steganographymethods employing embedded", U.S. Pat. No. 5,636, 292 are present.

Examples of the latter scheme of embedding a digital watermark in the frequency domain are an NTT scheme using the discrete cosine transform (Nakamura, Ogawa, & Takashima "Digital Watermarking Scheme in Frequency Domain for Copyright Protection of Digital Image", SCIS'97-26A, January 1997), a Defense Academy scheme using the discrete Fourier transform (Onishi, Oka, & Matsui, "Watermark Signature Method for Image Using PN Sequence", SCIS'97-26B, January 1997), a Mitsubishi/ Kyushu University scheme using the discrete wavelet transform (Ishizuka, Sakai, & Sakurai, "Experimental Examination About Security and Reliability of Digital Watermark Technique Using Wavelet Transform", SCIS'97-26D, January 1997), and a Matsushita scheme (Inoue, Miyazaki, Yamamoto, & Katsura, "Robustness of Digital Watermark Image Compression and Transformation Based on Wavelet Transform", SCIS'98-3.2.A, January 1998) In the above schemes, digital watermark embedding processing and extraction processing are in a one-to-one correspondence. The schemes are not compatible with each other. As is generally said, the technique of embedding a digital watermark in the space domain suffers little degradation in quality but is poor in resiliency, while the scheme using frequency transform suffers large degradation in quality but is excellent in resiliency. These schemes have different characteristic features, so some techniques are excellent in resiliency but can embed only a small amount of watermark information, and some techniques suffer little degradation in quality but are poor in resiliency. In addition, to protect information having a watermark, the algorithm for embedding the digital watermark, and information representing the embedding position or change amount (to be referred to as a key hereinafter) are often kept secret. This aims at increasing the resiliency against an intentional attack of trying to remove the digital watermark by analyzing the algorithm or embedding position.

A digital watermark is generally imperceptible to the human, though it is sometimes called an invisible digital watermark. In this case, a digital watermark that visibly synthetically displays a maker logo or the like on an original image is sometimes called a visible digital watermark.

As described above, there are various digital watermarking schemes.

Conventionally, no technique of managing the digital watermark information embedding scheme for image data on the basis of time information has been established. Hence, the digital watermarking scheme cannot be always optimized on the basis of the use period/use form of the image data.

In use of different digital watermarking schemes, even when watermark information embedded in an image is to be extracted, it cannot be done unless the scheme and version of digital watermark embedding are known in advance.

If an embedded watermark cannot be extracted, it cannot be determined whether the watermark is embedded by another scheme, or the embedded watermark is destroyed by an attack.

## SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above prior art, and has as its main object to provide a technique capable of always keeping digital watermark information embedded in image data by an optimum scheme on the basis of a time factor, or removing a digital watermark, or erasing the image data.

It is another object of the present invention to provide a data processing method and apparatus capable of efficiently coping with various digital watermarks and extracting the digital watermarks.

It is still another object of the present invention to provide a data processing method and apparatus capable of detecting various watermarks and also detecting whether the watermarks are destroyed by an attack or the like.

In order to attain the above described objects, a data processing apparatus of the present invention, comprises: holding means for holding image data having additional

information embedded as a digital watermark; detection means for detecting time information related to the image data; and change means for changing an embedding scheme for the additional information as the digital watermark embedded in the image data on the basis of the detected time information.

In a data processing apparatus of the present invention, the data processing apparatus for embedding a digital watermark into digital data, comprises: watermark embedding means for embedding watermark information to be embedded into the digital data; and common watermark embedding means for embedding, into the digital data, version information for specifying a version of an embedding scheme used by the watermark embedding means.

Further, in a data processing apparatus of the present invention, the data processing apparatus for extracting the watermark information from the digital data in which the watermark information is embedded by the above described data processing apparatus, comprises: common watermark extraction means for extracting the version information embedded by said common watermark embedding means; specifying means for specifying, on the basis of the version information extracted by the common watermark extraction means, the version of the embedding scheme with which the watermark information is embedded into the digital data; selection means for selecting watermark extraction means capable of extracting watermark information corresponding to the version specified by the specifying means; and control means for controlling to extract the watermark information from the digital data using the watermark extraction means selected by the selection means.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. **1** is a view showing the overall arrangement of an image processing apparatus applied to the first embodiment of the present invention;

FIG. **2** is a flow chart showing the flow of operation in a host computer according to the first embodiment when image data is input and managed on the basis of time information to be described later;

FIG. **3** is a flow chart showing a digital watermark embedding procedure in the first embodiment;

FIG. **4** is a view for explaining a processing example of steps **S303** and **S304** in the first embodiment;

FIG. **5** is a view for explaining a processing example of step **S207** in the first embodiment;

FIG. **6** is a view for explaining a processing example of steps **S303** and **S304** in the second embodiment of the present invention;

FIG. **7** is a view for explaining a processing example of step **S207** in the second embodiment of the present invention;

FIG. **8** is a view showing the overall arrangement of an image processing apparatus applied to the sixth embodiment of the present invention;

FIG. **9** is a view for explaining digital watermark embedding processing according to the seventh embodiment of the present invention;

FIGS. **10A** and **10B** are block diagrams for explaining common digital watermark embedding and extraction according to the seventh embodiment;

FIG. **11** is a view for explaining digital watermark extraction processing according to the seventh embodiment of the present invention;

FIG. **12** is a flow chart for explaining digital watermark embedding processing according to the seventh embodiment of the present invention;

FIG. **13** is a flow chart for explaining digital watermark extraction processing according to the seventh embodiment of the present invention;

FIG. **14** is a view for explaining digital watermark embedding processing according to the eighth embodiment of the present invention;

FIG. **15** is a view for explaining digital watermark extraction processing according to the eighth embodiment of the present invention;

FIG. **16** is a view for explaining digital watermark information in the eighth embodiment;

FIG. **17** is a flow chart for explaining digital watermark embedding processing according to the eighth embodiment of the present invention; and

FIG. **18** is a flow chart for explaining digital watermark extraction processing according to the eighth embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described below in detail with reference to the accompanying drawings. The embodiments will be described assuming that digital data is image data. As such digital data, not only image data but also any other digital data such as audio data or document data can be used.

[First Embodiment]

FIG. **1** is a view showing the overall arrangement of an image processing apparatus applied to the first embodiment of the present invention.

Referring to FIG. **1**, a host computer **1000** is, e.g., a popular personal computer, which can input, edit, and save an image read by a scanner **1002**. The image obtained here can be printed by a printer **1003**. Various user's manual instructions are input from a mouse **1004** or keyboard **1005**.

In this host computer **1000**, blocks (to be described later) are connected through a bus **1100** to allow exchange of various data.

Referring to FIG. **1**, a CPU **1101** controls the operations of the internal blocks or executes a program internally stored. A ROM **1102** stores in advance an image processing program and the like executed by the CPU **1101**. A RAM **1103** temporarily stores a program or various data to be processed for processing by the CPU **1101**. The RAM **1103** also has a function of holding current time information generated by a time generator such as a timer **1113** while updating it in units of 1/n sec. A hard disk (HD) **1104** stores a program or image data to be transferred to the RAM **1103** or the like, or saves processed image data. A monitor **1105** displays the processing situation while execution of various programs is progressing or displays image data before or after various processing operations. A scanner interface (I/F) **1106** connected to the scanner for reading an original or film by a CCD and generating image data receives the image data obtained by the scanner. A printer interface (I/F) **1107** connected to the printer **1003** capable of printing image data

held in the host computer **1000** outputs image data to the printer **1003**. A CD drive **1108** can read/write data from/onto a CD (or CD-R) as an external storage medium. An FD drive **1109** reads/writes data from/onto the FD **1109**, like the CD drive **1108**. A DVD drive **1110** also can read/write data from/onto a DVD, like the CD drive **1108**. An interface (I/F) **1111** is connected to the mouse **1004** or keyboard **1005** to receive an instruction input therefrom. A transmission device **1112** includes a model capable of transmitting image data held at a portion of the host computer **1000** to an external device or receiving image data from the external device.

An image data management method in the first embodiment will be described below.

FIG. **2** shows the flow of operation in the host computer **100** when image data is input and managed on the basis of time information (to be described later).

Image data is input in step **S201**. In this case, the image data is input by reading an original by the scanner **1002**, loading image data from the CD **1108**, FD **1109**, or DVD **1110**, or receiving image data from the transmission device **1112**. The input image data is temporarily stored in the RAM **1103** for the next processing. When the capacity of the RAM **1103** is smaller than the data amount of the image data, the HD **1104** is also used.

The flow advances to step **S202** to embed digital watermark information into the temporarily stored image data. The digital watermark information embedding method will be described with reference to FIG. **3**.

FIG. **3** is a flow chart showing the internal operation of step **S202** in FIG. **2**.

The time information of the image data is acquired in step **S301**. In the first embodiment, this time information is information representing the time when the host computer **1000** starts using the image data, i.e., the time when the image data is input in step **S201** (or the time when the digital watermark information is embedded in step **S202**, which is counted by the timer **1113**). In this case, the time information can be obtained by looking up time information updated and stored in the RAM **1103**. The time information acquisition method is not limited to this. If image data is input from the transmission device **1112**, time information may be simultaneously received. Additional information may be received by a bar code/optical card/magnetic card reader or the like. The time information can be the date and time of creation of the image data by the copyright holder in place of the input date and time of the image data, or if the image data is for sale, the date and time of sale of the image data. The time information obtained by one of the above methods is stored in the RAM **1103** as information to be embedded into the input image data.

The flow advances to step **S302** to acquire additional information related to the image data and store the information in the RAM **1103**. The additional information includes, e.g., the ID of the image data, copyright information (copyright holder or the like) or the input image data, and the attribute of the image (especially, information for limiting the use period/use form of the image data). The additional information can be input by the copyright holder of the image from the mouse **1004** or keyboard **1005** in FIG. **1**. When the image data is received from the copyright holder through the transmission device **1112**, the additional information may be simultaneously received. The additional information may be received by a bar code/optical card/magnetic card reader or the like. The additional information received by one of the above methods is stored in the RAM **1103** as information to be embedded into the input image data. The flow advances to step **S303** to embed the time information acquired in step **S301** into the image data as an invisible digital watermark. The flow advances to step **S304** to embed the additional information acquired in step **S302** into the image data as an invisible digital watermark.

In the first embodiment, the time information and additional information embedding processes (steps **S303** and **S304**) may be executed as separate processes. However, in the first embodiment, a description will be made assuming that these processes are simultaneously executed by the scheme shown in FIG. **4**.

Referring to FIG. **4**, reference numeral **1401** denotes input image data. In this case, the image data is assumed to be color image data. The image data **1401** is separated into R, G, and B color components **1402** to **1404** (four bit/pixel). The time information is embedded into the B component.

The above-described time information is converted into a monochrome (binary) image **1406** shown in FIG. **4** and held in the RAM **1103**. The above-described additional information is also converted into a monochrome (binary) image **1407** and held in the RAM **1103**. In the image **1406** or **1407**, identical pieces of time information or additional information are present periodically in the image. Hence, the time information or additional information can be detected from only part of the image **1406** or **1407**. For the descriptive convenience, the time information and additional information to be embedded are converted into simple images. However, binary images which are obtained by encrypting the images **1406** and **1407** and have the same sizes as theirs may be used in place of these images **1406** and **1407**.

When the B component **1404** is expressed by four bits per pixel, it can be separated into four bit planes **1405***a* to **1405***d*. The bit plane **1405***a* corresponds to the most significant bit and the bit plane **1405***d* to the least significant bit both in expressing the pixel density by four bits.

In the first embodiment, the second lower bit plane **1405***c* obtained here is replaced with the image **1406** obtained by converting the time information to form a bit plane **1406'** (step **S303**), and the least significant bit plane **1405***d* is replaced with the image **1407** obtained by converting the additional information to form a bit plane **1407'** (step **S304**).

That is, the bit planes **1405***a*, **1405***b*, **1406'**, and **1407'** are subsequently used as four bit planes of the B component. The B component reconstructed by the above way is represented as a B component **1404'**. The image undergoes no perceptible change because only the lower two bits are different between the B components **1404** and **1404'**. Hence, this can be an invisible digital watermark.

In the first embodiment, the B component is expressed by a four-bit density for the descriptive convenience. However, when the input image is expressed as a full-color image (eight-bit density for each color), degradation in visual characteristics becomes smaller by the same processing as described above.

Referring to FIG. **4**, finally, image data **1401'** reconstructed from the R component **1402**, G component **1403**, and B component **1404'** of the input image data is transferred to the next processing. With this processing, the time information and additional information can be embedded into the input image data.

The present invention is not limited to the above-described embodiment. For example, the input image can be not a color image but a monochrome image. In this case, the present invention can be realized by forcibly separating the monochrome image into R, G, and B components and processing them according to the procedure as described above. The embedding method is not limited to the above

embodiment, either. For example, the image **1406** representing time information may be replaced with not the bit plane **1405***c* but the bit plane **1405***d*, and the image **1407** representing additional information may be replaced with not the least significant bit plane **1405***d* but the bit plane **1405***c*. However, to so embed time information as to be unnoticeable to the human eye, a bit as low as possible is preferably selected as a bit to be replaced.

When the above embedding operation (steps **S202** and **S301** to **S304**) is ended, the resultant image data (image data having time information and additional information embedded therein) is held by the HD **1104** and set as one of images to be managed by the host computer **1000** (step **S203**). The held image can be displayed on the monitor **1105** anytime.

When storage of the image data in step **S203** is ended, the host computer **1000** continues to manage the image data. More specifically, each image data held in the HD **1104** is automatically extracted every predetermined time (one month/one week/one day/one hour), and time information is extracted from each image data. This extraction processing is done according to the procedure opposite to that for the time information embedding processing executed in step **S202**. More specifically, image data from which time information is to be extracted is separated into R, G, and B components shown in FIG. **4**, and the third bit plane **1405***c* of the B component is extracted, thereby detecting embedded time information.

In the first embodiment, the additional information (corresponding to the image **1407** in FIG. **4**) of the image data is also detected simultaneously with the processing in step **S205**, and the attribute of the image is also acquired (particularly, information for limiting the use period/use form of the image data).

The flow advances to step **S206** to determine in consideration of the attribute of the image whether the time information from which the time information is extracted must be processed or which processing is to be executed.

As a detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be unlimitedly used for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data can be used with a visible watermark", and the determined time in step **S206** (current time information in the RAM **1103**) is "Feb. 29, 2000", the processing advances from step **S206** to step **S207** as "case a". That is, the flow advances to processing of changing the scheme of the digital watermark embedded in the image data.

On the other hand, in the same attribute and determined time of this image, when the time information is "Feb. 24, 2000", the digital watermarking scheme need not particularly be changed. The flow returns from step **S206** to step **S204** as "case b", so the processing from step **S205** is re-executed after the elapse of the predetermined time.

As another detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be unlimitedly used for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data cannot be used", and the determined time in step **S206** is "Feb. 29, 2000", the processing advances from step **S206** to step **S209** and then to step **S210** as "case c". In step **S210**, the image data itself is deleted from the HD **1104**.

As still another detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data is in the managed state for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data is set in the unmanaged state", and the determined time in step **S206** is "Feb. 29, 2000", the processing advances from step **S206** to step **S209** and then to step **S211** as "case d". In step **S211**, the image data itself is kept stored in the HD **1104** but excluded from data to be managed (operation in FIG. **2**) every predetermined time.

A variety of situations are plausible for the above processing/determination, and the image attributes may be combined.

For example, such an image attribute may be set that "after the image is input to the host computer **1000**, the image data is unlimitedly usable for the first 10 days, usable with a visible watermark for the next 10 days, and then is set in the unmanaged state". In this case, when the time information detected in step **S205** is "Feb. 19, 2000", and the determined time in step **S206** is "Feb. 25, 2000", "case b" is selected. When the determined time is "Feb. 29, 2000", "case a" is selected because it is the 11th day of use. When the determined time is "Mar. 10, 2000", "case d" is selected. That is, according to the elapse of time, appropriately, the digital watermarking scheme can be changed, or the image can be deleted or excluded from data to be managed.

In step **S207** executed in "case a", the digital watermarking scheme of the image data to be processed is changed. One scheme for this will be described.

FIG. **5** shows a state wherein for image data having both time information and additional information embedded as invisible digital watermarks, the additional information is changed to a visible digital watermark while keeping the time information unchanged from the invisible digital watermark.

Referring to FIG. **5**, the image data **1401'** has time information and additional information embedded, as already described with reference to FIG. **4**. This image data **1401'** is separated into R, G, and B components, and then, the B component **1404'** in which the pieces of information are embedded is separated into bit planes. The bit planes **1405***a*, **1405***b*, **1406**, and **1407** are the same as in FIG. **4**. When the upper bit planes **1405***a* and **1405***b* are ORed in units of pixels using the binary image **1407** corresponding to the least significant bit plane, the image **1407** representing the additional information in the B component can be made visible. That is, bit planes **1405***a'* and **1405***b'* obtained by this OR processing correspond to bit planes obtained by synthesizing the original bit planes **1405***a* and **1405***b* with the binary image **1407** of the additional information. A B component **1404"** reconstructed using the bit planes **1405***a'*, **1405***b'*, **1406**, and **1407** obtained here is subsequently used in place of the original B component **1404'**.

On the other hand, four bit planes of each of the R and G components are also ORed using the binary image **1407** of the additional information to form images synthesized with the image **1407**. Image data **1401"** is reconstructed using the R, G, and B components **1402'**, **1403'**, and **1404"** obtained by the above processing. This image data **1401"** is subsequently used in place of the image data **1401'**.

In the first embodiment, the simplified scheme incapable of completely reconstructing the image has been described for the descriptive convenience. However, the present invention is not limited to this, and a scheme capable of completely reconstructing the image may be applied. For example, the image can be appropriately completely reconstructed by attaching the bit planes **1405***c* and **1405***d* as part of the original image to the image data **1401"**.

When step **S207** in FIG. **2** is ended, the resultant image data **1401"** is stored in the HD **1104** in place of the image data **1401'** (step **S208**). When the image data **1401"** is displayed on the monitor **1105**, the additional information is displayed so it is discernible by the human eye.

With the above operation, the image data input to the host computer **1000** is managed.

As described above, according to the first embodiment, in inputting, receiving, or purchasing image data, information for limiting the use period/use form of the image data is set by the copyright holder or the like whereby the image data can be managed in the apparatus (host computer **1000**) such that the image data is reliably used complying with the use period/use form.

[Second Embodiment]

In the first embodiment, as the first additional information embedding scheme, an invisible digital watermark is embedded. However, the present invention is not limited to this. For example, invisible digital watermark information is embedded in step **S303**, though a visible digital watermark may be embedded in step **S304**. In this case, in the digital watermarking scheme changing processing in step **S207**, a visible digital watermarking scheme can be replaced with an invisible digital watermarking scheme, unlike the first embodiment in which the invisible digital watermarking scheme is changed to the visible digital watermarking scheme. A method in this case will be briefly described.

The basic arrangement of the second embodiment is the same as in FIG. **1**, and a detailed description thereof will be omitted. The operation procedure for managing image data is also basically the same as that of the first embodiment (FIGS. **2** and **3**), and a detailed description thereof will be omitted.

Image data is input and stored in step **S201**. The flow advances to step **S202** to embed digital watermark information into the temporarily stored image data. This digital watermark information embedding method is also the same as in FIG. **3**. A detailed example of the operations in steps **S303** and **S304** will be described with reference to the accompanying drawings.

FIG. **6** shows a state wherein additional information is embedded as a visible digital watermark as the first digital watermark information embedding method in step **S202** of FIG. **2**.

Referring to FIG. **6**, reference numeral **1601** denotes an image corresponding to the image data **1401** described in the first embodiment, in which each of the R, G, and B components is expressed by four bits. This image data is segmented into regions **1602**. Additional information is to be embedded into a region, and time information is to be embedded into another region. A partial image **1602***b* corresponding to the region where the additional information (visible watermark information) is to be embedded is output as "attached data a" which is used to reconstruct the original image later as needed. This "attached data a" is attached to image data **1601'** after conversion (to be described later). The partial image **1602***b* is also used as lookup information for embedding visible watermark information (to be described later).

On the other hand, for partial images **1602***a* and **1602***c* where time information (invisible watermark information) is to be embedded, components (R and G components) except the B component to be deformed to embed the invisible watermark are output as data used to construct the image data **1601'** (to be described later). The partial images **1602***a* and **1602***c* corresponding to the B component are separated into four bit planes **1605***a* to **1605***d*, as in FIG. **4**. The relatively lower bit plane **1605***c* is replaced with a binary image **1603** of time information obtained according to the same procedure as in the above-described first embodiment.

The bit planes **1605***a* to **1605***d* and image **1603** have no image data corresponding to the partial image **1602***b*.

A new B component **1606** is formed by the four resultant bit planes **1605***a*, **1605***b*, **1603**, and **1605***d* and output as the image data of the B component corresponding to the images **1602***a* or **1602***c* of the R or G component.

To construct the image data **1601'** corresponding to an image obtained by embedding digital watermark information into the original image, an image (image in which the additional information is embedded as a visible watermark) replacing the partial image **1602***b* is generated. This is executed by synthesizing each of the bit planes (12 bit planes) of the R, G, and B components of the original image **1602***b* with the image **1604** obtaining by binarizing the additional information into an image having the same size as that of the original image **1601**, as shown in FIG. **6**. The generated image having the same size as that of the partial image **1602***b* (size corresponding to the central portion of the image **1601**) is expressed as an image **1607**.

The additional information is output as "attached data b" coded in consideration of later use.

When an image similar to the original image **1601** is reconstructed using the image data **1602***a* (only the R and G components), **1602***c* (only the R and G components), **1606**, and **1607** obtained by the above processing, the image **1601'** in which the additional information is added to the central portion of the image visibly to the human eye, and the time information is added to the upper and lower portions of the image invisibly to the human eye can be generated.

The resultant image **1601'** is held in aHD **1104** together with the "attached data a" and "attached data b" and set as one of images to be managed by a host computer **1000** (step **S203**), as in the first embodiment. The held image can be displayed on a monitor **1105** anytime.

When storage of the image data in step **S203** is ended, the host computer **1000** continues to manage the image data. This arrangement is also the same as in the first embodiment. More specifically, each image data held in the HD **1104** is automatically extracted every predetermined time, and time information is extracted from each image data. This extraction processing is done according to the procedure opposite to that for the time information embedding processing executed in step **S202**. In the second embodiment, the B component at the upper and lower portions of the image data **1601'** from which time information is to be extracted, and the image **1603** representing the time information corresponding to the third bit plane of the B component is extracted, thereby detecting the time information.

In the second embodiment as well, the additional information (corresponding to the image **1604** in FIG. **6**) of the image data is also detected simultaneously with the processing in step **S205**, and the attribute of the image is also acquired (particularly, information for limiting the use period/use form of the image data).

The flow advances to step **S206** to determine in consideration of the attribute of the image whether the time information from which the time information is extracted must be processed or which processing is to be executed.

As a detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be used with a visible watermark for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data can be used with an invisible watermark", and the determined time in step **S206** (current time information in a RAM **1103**) is "Feb. 29, 2000", the processing advances from step **S206** to step **S207** as "case a". That is, the flow advances to processing of changing the scheme of the digital watermark embedded in the image data.

On the other hand, in the same attribute and determined time of this image, when the time information is "Feb. 24, 2000", the digital watermarking scheme need not particularly be changed. The flow returns from step S206 to step S204 as "case b", so the processing from step S205 is re-executed after the elapse of the predetermined time.

As another detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be used with a visible watermark for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data cannot be used", and the determined time in step S206 is "Feb. 29, 2000", the processing advances from step S206 to step S209 and then to step S210 as "case c". In step S210, the image data itself is deleted from the HD 1104.

As still another detailed example, when the detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data is in the managed state for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data is set in the unmanaged state", and the determined time in step S206 is "Feb. 29, 2000", the processing advances from step S206 to step S209 and then to step S211 as "case d". In step S211, the image data itself is kept stored in the HD 1104 but excluded from data to be managed (operation in FIG. 2) every predetermined time.

A variety of situations are plausible for the above processing/determination, and the image attributes may be combined.

For example, such an image attribute may be set that "after the image is input to the host computer 1000, the image data is usable with a visible watermark for the first 10 days, usable with an invisible watermark for the next 10 days, and then is set in the unmanaged state". In this case, when the time information detected in step S205 is "Feb. 19, 2000", and the determined time in step S206 is "Feb. 25, 2000", "case b" is selected. When the determined time is "Feb. 29, 2000", "case a" is selected because it is the 11th day of use. When the determined time is "Mar. 10, 2000", "case d" is selected.

In step S207 executed in "case a", the digital watermarking scheme of the image data as the processing target is changed. One scheme for this in the second embodiment will be described next.

FIG. 7 shows a state wherein the image data 1601' in which time information is embedded as an invisible digital watermark, and additional information is embedded as a visible digital watermark is changed to image data which has additional information as an invisible digital watermark.

Referring to FIG. 7, in the image data 1601', the time information and additional information are already embedded according to the procedure shown in FIG. 6. The image data 1601' has the "attached data a" and "attached data b" shown in FIG. 6.

First, the "attached data a" (1602*b*) is separated into R, G, and B components (1702R, 1702G, and 1702B). The B component 1702B to be converted in embedding the invisible digital watermark is separated into bit planes. Of bit planes 1704*a* to 1704*d* obtained here, the third upper bit plane 1704*c* is replaced with an image 1705 which is obtained by binarizing the "attached data b" (code of the additional information) and has the same size as that of the B component 1702B.

This method for this process is the same as in the above-described first embodiment. A B component 1702B' similar to the B component 1702B is reconstructed using the four resultant bit planes 1704*a*, 1704*b*, 1705, and 1704*d*. Image data 1602' similar to the "attached data a" 1602*b* is reconstructed using the reconstructed B component 1702B, R component 1702R, and G component 1702G and used as the central portion of the image 1601'. That is, the upper portion 1701 and lower portion 1703 of the image 1601' are used without any change, and the central portion of the image 1601' is replaced with the image data 1602'. With this processing, an image 1601" in which both time information and additional information are embedded as invisible watermark information is generated.

When step S207 in FIG. 2 is ended, the resultant image data 1601" is stored in the HD 1104 in place of the image data 1601' (step S208). When the image data 1601" is displayed on the monitor 1105, the additional information is displayed so it is not discernible by the human eye.

With the above operation, the image data input to the host computer 1000 is managed.

According to the second embodiment, in inputting, receiving, or purchasing image data, information for limiting the use period/use form of the image data is set by the copyright holder or the like whereby the image data can be managed in the apparatus (host computer 1000) such that the image data is reliably used complying with the use period/use form.

[Third Embodiment]

In the first and second embodiments, the method of embedding additional information into an image as a digital watermark (visible watermark/invisible watermark) is changed in step S207 of FIG. 2 by managing time information. However, the present invention is not limited to this.

For example, additional information embedded as a digital watermark can be removed by managing time information.

This processing can be executed by replacing the "attached data a" with the central portion of the image 1601' in processing of step S207 (processing in FIG. 7) in the second embodiment.

As a detailed example, when detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be used with a visible watermark for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data can be used with the watermark of additional information removed", and the determined time in step S206 (current time information in a RAM 1103) is "Feb. 29, 2000", the processing advances from step S206 to step S207 as "case a". In step S207, processing of executing the above-described additional information is executed, unlike the first and second embodiments.

[Fourth Embodiment]

In the first and second embodiments, in step S207 of FIG. 2, the method of embedding additional information into an image as a digital watermark is changed from a visible watermark to an invisible watermark or from an invisible watermark to a visible watermark. However, the present invention is not limited to this and also incorporates a change from a first invisible watermark method to a second invisible watermark method.

As a simple example, in the embedding method shown in FIG. 4, which is applied to the first embodiment, after image data 1401' is separated into bit planes 1402, 1403, and 1404' and further separated into bit planes 1405*a*, 1405*b*, 1406, and 1407, an image 1407' which appears to be different may be generated by rotating the bit plane 1407 through 180° or converting the bit plane 1407 into a mirror image, and the image 1401' similar to the original image may be reconstructed using the image 1407'. As another example, when the lower two bits of the bit planes 1405*a*, 1405*b*, 1406, and 1407 obtained by bit plane separation are exchanged with

each other, and a B component similar to the image **1404'** is reconstructed again using the **1405*a***, **1405*b***, **1407**, and **1406** in this order, thereby reconstructing the image **1401'**, the first invisible watermark can be changed to the second invisible watermark.

As a detailed example, when detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be used with additional information embedded by the first invisible watermarking scheme for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data can be used with the additional information embedded by the second invisible watermarking scheme", and the determined time in step **S206** (current time information in a RAM **1103**) is "Feb. 29, 2000", processing advances from step **S206** to step **S207** as "case a". In step **S207**, the additional information is changed from the first invisible watermark to the second invisible watermark by the above-described method.

[Fifth Embodiment]

The present invention also incorporates a change from a first visible watermark method to a second visible watermark method in step **S207** of FIG. **2**, unlike the fourth embodiment.

In the fifth embodiment, a simple example in which an image (**1602'**) having additional information embedded by the second visible watermark method is generated from an image (**1601'**) having additional information embedded by the first visible watermark method will be described.

For example, when the image data **1601'** shown in FIG. **6** (FIG. **7**) has additional information embedded by the first visible watermarking scheme, an upper portion **1701** and lower portion **1703** are directly used to reconstruct the image **1602'**. Several processing operations below are executed to construct the central portion of the image **1602'**. First, a binary image **1604'** having a display form (font, font size, and the like) different from that of an image **1604** in FIG. **6** is newly generated from "attached data b" (additional information). This image **1604'** and each of the bit planes (12 bit planes) of the R, G, and B components of "attached data a" (**1602*b***) are ORed, thereby newly obtaining a partial image **1602*b***" having the additional information embedded by the second visible watermarking scheme. When an image is reconstructed using the resultant partial image **1602"**, upper portion **1701**, and lower portion **1703**, the image **1602'** having the additional information embedded by the second visible watermark method can be obtained.

As a detailed example, when detected time information is "Feb. 19, 2000", the detected attribute of the image is "the image data can be used with additional information embedded by the first visible watermarking scheme for 10 days (until Feb. 28, 2000), and after that (from Feb. 29, 2000), the image data can be used with the additional information embedded by the second visible watermarking scheme", and the determined time in step **S206** (current time information in a RAM **1103**) is "Feb. 29, 2000", processing advances from step **S206** to step **S207** as "case a". In step **S207**, the additional information is changed from the first visible watermark to the second visible watermark by the above-described method.

[Sixth Embodiment]

In the above embodiments, operation is performed in the host computer **1000** shown in FIG. **1**, i.e., a so-called personal computer using a program for executing the above procedure, which is mainly stored in the CPU or ROM. However, the present invention is not limited to this.

For example, the processing of each of the above embodiments may be executed by arranging an image input section **1801** as the image data input function in step **S201** by a scanner **1002**, CD **1108**, FD **1109**, DVD **1110**, or transmission device (at the time of reception) **1112**, a digital watermark embedding/extraction section **1802** as the digital watermark embedding/digital watermark information extraction/digital watermarking scheme changing (digital watermark removal) function in steps **S202**, **S205**, and **S207**, an image holding section **1803** as the same function as that of an HD **1104**, and a time management section **1804** as the current time management function and various control functions in steps **S204** to **S211**, as shown in FIG. **8**.

[Modification to Embodiment]

The present invention is not limited to the case described in the above embodiments in which time information is held as a digital watermark. The main characteristic feature of the embodiments is that the presence/absence and scheme of a digital watermark embedded in an image are managed in consideration of a time element. Hence, the time information can be either simply attached to each image data as attached information in an encrypted/encoded state or held in the apparatus. However, when the time information is embedded in a given image as a digital watermark, as described above, the image can always be managed without making the user know the presence of the time information.

As described above, according to this embodiment, for image data having digital watermark information embedded, the digital watermark information can always be kept embedded in the image data by an optimum scheme on the basis of a time factor, the digital watermark can be removed, or the image data can be erased.

[Seventh Embodiment]

In the following embodiment, techniques capable of properly extracting a digital watermark from image data in which the digital watermark is embedded by one of embedding schemes of a number of types or versions will be described. The techniques to be described in the following embodiments can also be applied to extract or embed a digital watermark in the above embodiments.

FIG. **9** is a view for explaining digital watermark embedding processing according to the seventh embodiment of the present invention and, more particularly, an example in which watermark embedding sections for embedding watermarks by digital watermark embedding schemes of different types or versions and a common watermark embedding section for embedding a common digital watermark are arranged.

Referring to FIG. **9**, reference numerals **101** to **104** denote digital watermark embedding sections for embedding watermarks by digital watermark embedding schemes of different types or versions; **105**, a common watermark embedding section for embedding a digital watermark by a common scheme; and **110**, data to be distributed.

The common watermark embedding section **105** has the following characteristic features.

1) The common watermark embedding section **105** embeds a resilient digital watermark using a relatively small amount of information.

2) The common watermark embedding section **105** embeds a digital watermark which can be extracted without any key or using a common key.

3) The common watermark embedding section **105** embeds information for specifying at least a digital watermarking scheme and/or its version.

4) The common watermark embedding section **105** embeds a digital watermark having resiliency against another digital watermark embedding (e.g., the embedding position is changed).

Various schemes can be employed as the common watermark embedding scheme having the above characteristic features. An example will be described below to explain the high resiliency. When input data as a copyrighted work is a still image, the image data of the still image is segmented into blocks each formed from 8×8 pixels, and DCT (Discrete Cosine Transform) is executed in units of blocks. A block that has under gone the DCT will be referred to as a DCT coefficient block, one coefficient of a DCT coefficient block will be referred to as a DCT coefficient, and a set of DCT coefficient blocks of one image will be referred to as a DCT coefficient block group.

FIG. **10**A is a block diagram for explaining the arrangement of the common watermark embedding section **105**.

Referring to FIG. **10**A, an input image x undergoes the DCT by an image converter **301**, and a DCT coefficient block group as an output is used as the input to a digital watermark embedding device **302**. A DCT coefficient block where a digital watermark is to be embedded is selected from the DCT coefficient block group, and one DCT coefficient in the DCT coefficient block is quantized, thereby embedding one watermark bit. At this time, the magnitude of the quantization step determines the embedding strength, and the magnitude of the quantization step and the position of the selected DCT coefficient correspond to key information.

Let s{u,v} be the value of a DCT coefficient at coordinates u and v, and h be the quantization step. According to the following rule, "0" or "1" as digital watermark bit is embedded.

A value a satisfying

$$a \cdot h < s\{u,v\} \leq (a+1) \cdot h \quad (1)$$

will be obtained.

$$\text{When embed bit is 0, } c\{u,v\} = b \cdot h + h/2 \quad (2)$$

(b is an even value of a and (a+1))

$$\text{When embed bit is 1, } c\{u,v\} = b \cdot h + h/2 \quad (3)$$

(b is an odd value of a and (a+1))

With this operation, c{u,v} is obtained as a DCT coefficient after embedding the digital watermark.

Finally, IDCT (inverse DCT) is performed for the block group using an image inverse-converter **303** to restore and reconstruct the original 8×8 blocks.

To extract the thus embedded common digital watermark, as shown in FIG. **10**B, the same DCT as in embedding the digital watermark is executed using the image converter **301**, and the embedded DCT coefficient is selected for the DCT coefficient block group as the output from the image converter **301** using key information to obtain a value b satisfying

$$b \cdot h < c\{u,v\} \leq (b+1) \cdot h \quad (4)$$

If the value b is even, it is determined that the embedded bit is "0". If the value is odd, it is determined that the embedded bit is "1".

The following techniques can be used to increase the resiliency in such a digital watermark embedding scheme.

In selecting one DCT coefficient to be embedded from the DCT coefficient block group, when a DCT coefficient representing a low-frequency component is selected, the resiliency of the watermark can be increased. This is because high-frequency components are readily lost by image compression or various filtering operations, though low-frequency components are not.

In the above embedding scheme, one DCT coefficient block is selected, or one DCT coefficient is embedded. However, the resiliency can also be increased by increasing the number of DCT coefficient blocks or DCT coefficients. The reason for this is as follows. If one bit is simply embedded into one DCT coefficient, its value is probably lost by image compression or various filtering operations. However, when identical bits are embedded into a plurality of DCT coefficients, all the bits are hardly lost.

The resiliency can also be increased by encoding the bit itself to be embedded using an error-correction code. This is because even when some embedded bits are lost, the bits are reconstructed by the error-correction codes. Obviously, the higher the correction capability of the error-correction code is, the higher the resiliency becomes. Although these techniques increases the resiliency, low-frequency components of the image may change, or the image quality may degrade because a number of bits are embedded. In addition, the number of embeddable bits often decreases because identical bits are embedded using a number of DCT coefficients.

With an opposite operation, a digital watermark technique for a higher image quality and larger amount of embeddable information can be realized, although the resiliency becomes low.

Such tendency in the technique of increasing resiliency is observed not only in the technique using the DCT but also in a technique using the wavelet transform or Fourier transform or a technique of directly manipulating the luminance values of pixels.

The embedding procedure according to the seventh embodiment will be described next with reference to FIG. **9**. In this case, information which is embedded by the common watermark embedding section **105** to specify the embedding technique (section) used to actually embed a watermark is defined as, e.g., "00 (=A)", "01 (=B)", "10 (=C)", or "11 (=D)". These pieces of information are 2-bit information for specifying the digital watermark techniques in the watermark embedding sections **101**, **102**, **103**, and **104**. However, another information may be set as these pieces of information.

First, bit information corresponding to one of the digital watermark embedding sections **101** to **104** to be used later is embedded using the common watermark embedding section **105** by the common digital watermark embedding technique having high resiliency and the characteristic features 1) to 4) for the data **110** to be distributed. After that, actual digital watermark information is embedded using one of the digital watermark embedding sections **101** to **104**, which is specified by the bit information.

The order of digital watermark embedding may be reversed as long as the specified digital watermark embedding scheme and common digital watermark embedding scheme do not interfere with each other, i.e., a technique which does not affect the common digital watermark information by the specified digital watermark embedding processing is used (including changing the embedding position). In addition, the information to be embedded may be changed or unchanged for each watermark embedding technique. Various watermark information can be embedded by each technique, including copyright information, user information, and identification information.

FIG. **11** is a view showing digital watermark extraction processing according to the seventh embodiment of the present invention.

Referring to FIG. **11**, digital watermark extraction sections **201** to **204** corresponding to the digital watermark embedding sections **101** to **104** shown in FIG. **9** can extract

watermark information embedded by the corresponding watermark embedding sections **101** to **104**. A common watermark extraction section **205** extracts a common watermark embedded in the distribution data **110** by the common digital watermark embedding section **105**.

Referring to FIG. **11**, if data **210** which may possibly be an illicit copy is detected or reported, watermark information embedded by a common digital watermark is extracted using the common watermark extraction section **205**. With this information, the digital watermarking scheme used to embed the digital watermark and/or its version is specified, and various pieces of embedded information are extracted using one of the digital watermark extraction sections **201** to **204**, which is specified by the information.

As is apparent from the seventh embodiment, digital watermark information can be efficiently extracted even in a system using different digital watermarking schemes. Additionally, even when the watermark cannot be detected, the security can be improved due to the following reasons.

If watermark information which should have been embedded in data cannot be detected, it is difficult to discriminate whether the data has no watermark information at all, a watermark is embedded by another watermark embedding scheme, or embedded watermark information is destroyed by an attack.

However, the common digital watermark of the seventh embodiment has high resiliency, and the common digital watermark information can hardly be destroyed by an attack. Hence, when watermark information by the common digital watermark is extracted, the possibility that the data has no digital watermark information at all is excluded.

Each technique can use an arbitrary digital watermark embedding scheme. However, if detailed information is embedded, the amount of embedded information is large. To suppress degradation in image quality by such a large amount of embedded information, a digital watermark is often embedded using a digital watermarking scheme with relatively low resiliency. Hence, if common digital watermark information is extracted by the common digital watermark extraction scheme, and the watermark information which should have been embedded by each watermark embedding section cannot be extracted, the embedded digital watermark information has probably been destroyed by an attack or the like.

FIG. **12** is a flow chart showing digital watermark embedding processing according to the seventh embodiment.

First, a digital watermark is embedded in the distribution data **110** using the common watermark embedding section **105** instep S1. The version of the embedding scheme to be used by the digital watermark embedding section for embedding a digital watermark next is specified by the common digital watermark. The flow advances to step S2 to embed a digital watermark in the distribution data **110** using the digital watermark embedding section (one of the digital watermark embedding sections **101** to **104**) of the version specified in step S1. Thus, distribution data having a digital watermark embedded can be created.

FIG. **13** is a flow chart showing processing of extracting the digital watermark for the data in which the digital watermark is embedded by the above method.

The common digital watermark embedded in the distributed data **210** is extracted in step S11. It is checked in step S12 whether the common digital watermark is extracted. If NO in step S12, the flow advances to step S13 to determine that the data **210** has no digital watermark at all, and the processing is ended.

If YES in step S12, the flow advances to step S14 to extract the digital watermark embedded by the watermark embedding technique of a version specified by the common digital watermark using a watermark extraction section (one of the digital watermark extraction sections **201** to **204**) corresponding to the technique. It is checked in step S15 whether the embedded digital watermark is normally extracted. If YES in step S15, the extracted digital watermark is employed, and the processing is ended. If NO in step S15, the flow advances to step S16 to determine that the embedded digital watermark is destroyed due to some reason.

As described above, according to the seventh embodiment, common watermark information is embedded using a common watermark embedding technique with high resiliency, and the version of the embedding scheme used by the watermark technique that has actually been used to embed the watermark information is specified by the common watermark information whereby the detectability of the embedded digital watermark can be increased as compared to a case wherein the digital watermark is embedded using only one of various digital watermark embedding techniques. In addition, it can be more reliably determined whether the digital watermark has been destroyed by an attack.

In the seventh embodiment, four digital watermark embedding techniques have been exemplified. However, this embodiment can be practiced for an arbitrary number of techniques.

[Eighth Embodiment]

FIG. **14** is a view for explaining digital watermark embedding processing according to the eighth embodiment of the present invention.

Referring to FIG. **14**, digital watermark embedding sections **401** to **404** embed a watermark in distribution data **410** by digital watermark embedding schemes of different types or versions. As a characteristic feature, information embedded using the digital watermarking scheme of one of the digital watermark embedding sections **401** to **404** cannot be or can hardly be extracted by another digital watermarking scheme. Generally, this characteristic feature holds for different digital watermarking schemes. However, if the number of types of digital watermarking schemes of the digital watermark embedding sections **401** to **404** used is relatively small, the digital watermarking schemes can be confirmed in advance by experiments and the like, and such a combination of digital watermarking schemes can be selected.

The digital watermark embedding procedure will be described below.

A digital watermark is embedded into the distribution data **410** using one of the digital watermark embedding sections **401** to **404**. The digital watermark embedding section to be employed is determined by the period for which the digital watermark embedding sections **401** to **404** are to be used, or for digital watermarking schemes with different versions, the period for which the digital watermark is to be embedded. The information embedded as the digital watermark contains information (specific information) determined by the digital watermark embedding sections **401** to **404**. For example, as shown in FIG. **16**, specific information (several bits) (e.g., "1111") is stored in a first embedding region **601**, and individual watermark information to be actually embedded is embedded in a remaining region **602**.

FIG. **15** is a view for explaining digital watermark extraction processing according to the eighth embodiment of the present invention.

Referring to FIG. **15**, reference numeral **501** to **504** denote digital watermark extraction sections capable of extracting watermarks embedded by the digital watermark embedding

sections **401** to **404** in FIG. **14**; and **510**, data in which a digital watermark is embedded according to the arrangement shown in FIG. **14**.

The digital watermark extraction procedure shown in FIG. **15** will be described below.

If data **510** which is assumed to be an illicit copy is detected or reported, a digital watermark embedded in the data **510** is extracted by the digital watermark extraction section **501** first. If the digital watermark cannot be extracted, a digital watermark is extracted sequentially using the digital watermark extraction sections **502** to **504**. When a digital watermark is extracted by one of the extraction sections, the obtained information is used as watermark information.

When no watermark information can be obtained by any digital watermark extraction section, it is determined that the data **510** has no digital watermark information at all. Whether the extracted information is watermark information is determined in accordance with the specific information.

For example, as shown in FIG. **16**, assume that it is predetermined that all the first bits (specific information) of the digital watermark are "1". In this case, when all the first bits of information extracted from the region **601** by one of the digital watermark extraction sections **501** to **504** are "1", and the information extracted from the remaining region **602** is significant information, it is determined that the extracted information is watermark information. This is because the digital watermark embedding sections **401** to **404** use exclusive watermark embedding schemes, and therefore, a digital watermark embedded by a certain watermark embedding scheme can hardly be extracted by another scheme as significant information containing such specific information.

When all the first bits of the information extracted from the region **601** by one of the digital watermark extraction sections **501** to **504** are "1", and the information extracted from the remaining region **602** is not significant information, it may be determined that the watermark information has been destroyed by an attack or the like.

FIG. **17** is a flow chart for explaining digital watermark embedding processing according to the eighth embodiment of the present invention.

First, one of the digital watermark embedding sections **401** to **404** for embedding a digital watermark into the distribution data **410** is selected. In this selection, the digital watermark section to be selected is determined by the period for which the digital watermark embedding sections **401** to **404** are to be used, or for digital watermarking schemes with different versions, the period for which the digital watermark is to be embedded. The flow advances to step S22 to embed a digital watermark into the data **410** using the selected digital watermark embedding section. Information embedded as a digital watermark contains information (specific information in the region **601** shown in FIG. **16**) determined by the digital watermark embedding sections **401** to **404**.

FIG. **18** is a flow chart showing digital watermark extraction processing according to the eighth embodiment.

When data **510** having a digital watermark embedded is input in step S31, the flow advances to step S32 to select the digital watermark extraction section **501** to extract the embedded digital watermark. The digital watermark embedded in the data **510** is extracted using the selected digital watermark extraction section **501** (step S33). The flow advances to step S34 to determine whether the digital watermark is extracted. If NO in step S34, the flow advances to step S36 to select one of the remaining digital watermark extraction sections **502** to **504**. The flow returns to step S33 to extract the digital watermark using the selected digital watermark extraction section. When the digital watermark is extracted from the data **510** using one of the digital watermark extraction sections **501** to **504**, the flow advances to step S35 to determine the obtained information as watermark information.

If the watermark information cannot be obtained using any one of the digital watermark extraction sections **501** to **504**, the flow advances from step S37 to step S38 to determine that no digital watermark information is embedded in the data **510** at all. Whether the obtained information is watermark information is determined in accordance with the specific information in the region **601**.

When the specific information is contained in the region **601**, and the information in the region **602** is insignificant information, it may be determined that the digital watermark is destroyed.

In the above-described seventh embodiment, a plurality of digital watermark embedding schemes can be easily mixed together without depending on individual digital watermarking schemes or the number of types thereof. However, there are two problems: the common watermark embedding scheme by the common digital watermark embedding section **105** cannot be improved, and two embedding schemes, i.e., common digital watermark embedding and individual digital watermark embedding must always be executed in the digital watermark embedding processing.

To the contrary, according to the eighth embodiment, since the common digital watermarking scheme is not used, digital watermark embedding can be done using a single digital watermark embedding section, and the common digital watermark embedding scheme need not be used. It is still time-consuming when the number of types of digital watermark embedding schemes is large. However, this technique is especially effective when the number of types of embedding schemes is relatively small, or only a digital watermark embedded by a specific embedding scheme need be extracted.

As described above, according to this embodiment, even when digital watermarking schemes of different types or versions are mixed together, the embedded digital watermark can be specified, and the watermark information can be extracted. This technique can effectively and efficiently cope with a case wherein a plurality of digital watermarking schemes become available as the digital watermarking scheme is improved.

Even when no watermark cannot be detected, data security can be improved, unlike the case wherein each digital watermarking scheme is used lonely.

The version information used in the seventh and eighth embodiments can be more effectively used, because of its characteristics, in combination with the technique described in the first to sixth embodiments in which "the digital watermark embedding method is changed in accordance with a time factor".

The present invention is not limited to the apparatuses and methods for implementing the above embodiments or a method that combines the methods described in the embodiments. The present invention also incorporates a case wherein the above embodiments are implemented by supplying software program codes for implementing the above embodiments to the computer (or the CPU or MPU) of the system or apparatus and causing the computer of the system or apparatus to operate various devices in accordance with the program codes.

In this case, the software program codes themselves implement the functions of the above embodiments, and the present invention incorporates the program codes them-

selves and a section for supplying the program codes to the computer and, more specifically, a storage medium which stores the program codes.

As a storage medium for storing the program codes, for example, a floppy disk, hard disk, optical disk, magnetooptical disk, CD-ROM, magnetic tape, nonvolatile memory card, ROM, or the like can be used.

The present invention also incorporates the program codes not only in a case wherein the functions of the above embodiments are implemented by controlling various devices by the computer in accordance with only the supplied program codes but also in a case wherein the above embodiments are implemented when the program codes cooperates with the OS (Operating System) or another application running on the computer.

The present invention also incorporates a case wherein the supplied program codes are stored in the memory of a function expansion board of the computer or a function expansion unit connected to the computer, and the CPU or the like of the function expansion board or function expansion unit executes part or all of actual processing on the basis of the instructions of the program codes, thereby implementing the above embodiments.

The embodiments have been independently described above. However, the present invention can be applied to an arrangement that uses the arrangement of one of the embodiments or appropriately combines the arrangements of the embodiments.

The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to apprise the public of the scope of the present invention, the following claims are made.

What is claimed is:

1. A data processing apparatus comprising:

holding means for holding image data having additional information embedded as a digital watermark;

detection means for detecting time information related to the image data; and

change means for changing an embedding scheme for the additional information as the digital mark, from an invisible watermarking scheme to a visible watermarking scheme, on the basis of the time information detected by said detection means.

2. The apparatus according to claim 1, further comprising embedding means for embedding the additional information into the image data as the digital watermark before the image data is held by said holding means.

3. The apparatus according to claim 1, wherein the time information contains current time information corresponding to a time of the detection.

4. The apparatus according to claim 1, wherein the time information contains information related to a time limit for use of the image data held by said holding means.

5. The apparatus according to claim 1, wherein an item of the time information is information embedded as a digital watermark in the image data held by said holding means.

6. The apparatus according to claim 1, wherein said change means changes the embedding scheme from a visible watermarking scheme to an invisible watermarking scheme.

7. A data processing apparatus comprising:

holding means for holding image data having additional information embedded as a digital watermark;

detection means for detecting time information related to the image data; and

change means for changing an embedding scheme for the additional information as the digital mark, from a first invisible watermarking scheme to a second invisible watermarking scheme, on the basis of the time information detected by said detection means.

8. A data processing apparatus comprising:

holding means for holding image data having additional information embedded as a digital watermark;

detection means for detecting time information related to the image data; and

change means for changing an embedding scheme for the additional information as the digital mark, from a first visible watermarking scheme to a second visible watermarking scheme, on the basis of the time information detected by said detection means.

9. A data processing method comprising:

a detection step of detecting time information related to image data having additional information embedded as a digital watermark; and

a change step of changing an embedding scheme for the additional information as the digital watermark, from a first invisible watermarking scheme to a second invisible watermarking scheme, on the basis of the time information detected at said detection step.

10. A computer-readable storage medium which stores a data processing program for executing a data processing method, said program comprising:

a detection step module for detecting time information related to image data having additional information embedded as a digital watermark; and

a change step module for changing an embedding scheme for the additional information as the digital watermark, from a first invisible watermarking scheme to a second invisible watermarking scheme, on the basis of the time information detected by said detection step module.

11. A data processing apparatus for extracting digital watermark information from digital data in which the watermark information is embedded by an apparatus having:

watermark embedding means for embedding watermark information to be embedded into the digital data; and

common watermark embedding means for embedding, into the digital data, version information for specifying a version of an embedding scheme used by said watermark embedding means, at high resiliency,

said data processing apparatus comprising:

common watermark extraction means for extracting the version information embedded by said common watermark embedding means;

specifying means for specifying, on the basis of the version information extracted by said common watermark extraction means, the version of the embedding scheme with which the watermark information is embedded into the digital data;

selection means for selecting watermark extraction means capable of extracting watermark information corresponding to the version specified by said specifying means; and

control means for controlling to extract the watermark information from the digital data using said watermark extraction means selected by said selection means.

12. A data processing apparatus for extracting watermark information from digital data in which the watermark information is embedded by an apparatus having:

watermark embedding means for embedding watermark information to be embedded into the digital data;

transformation means for performing discrete frequency transformation for the digital data;

embedding means for embedding version information for specifying a version of an embedding scheme used by said watermark embedding means at high resiliency, by quantizing a transform coefficient transformed by said transformation means; and

inverse transformation means for performing inverse transformation means for the digital data having the version information embedded by said embedding means,

said data processing apparatus comprising:

common watermark extraction means for extracting the version information embedded by said common watermark embedding means;

specifying means for specifying, on the basis of the version information extracted by said common watermark extraction means, the version of the embedding scheme with which the watermark information is embedded into the digital data;

selection means for selecting watermark extraction means capable of extracting watermark information corresponding to the version specified by said specifying means; and

control means for controlling to extract the watermark information from the digital data using said watermark extraction means selected by said selection means.

13. A data processing method of extracting watermark information from digital data in which the watermark information is embedded by a method having:

a watermark embedding step of embedding watermark information to be embedded into the digital data; and

a common watermark embedding step of embedding, into the digital data, version information for specifying a version of an embedding scheme used in the watermark embedding step, at high resiliency,

said data processing method comprising:

a common watermark extraction step of extracting the version information embedded in the common watermark embedding step;

a specifying step of specifying, on the basis of the version information extracted in the common watermark extraction step, the watermark embedding technique with which the watermark information is embedded into the digital data;

a selection step of selecting a watermark extraction technique for extracting watermark information corresponding to the watermark embedding technique specified in the specifying step; and

a control step of controlling to extract the watermark information from the digital data using the watermark extraction technique selected in the selection step.

14. A data processing method of extracting watermark information from digital data in which the watermark information is embedded by a method having:

a watermark embedding step of embedding watermark information to be embedded into the digital data;

a transformation step of performing discrete frequency transformation for the digital data;

an embedding step of embedding version information by quantizing a transform coefficient transformed in the transformation step; and

an inverse transformation step of performing inverse transformation of the transformation step for the digital data having the version information embedded at said embedding step,

said data processing method comprising:

a common watermark extraction step of extracting the version information embedded in the common watermark embedding step;

a specifying step of specifying, on the basis of the version information extracted in the common watermark extraction step, the watermark embedding technique with which the watermark information is embedded into the digital data;

a selection step of selecting a watermark extraction technique for extracting watermark information corresponding to the watermark embedding technique specified in the specifying step; and

a control step of controlling to extract the watermark information from the digital data using the watermark extraction technique selected in the selection step.

15. A computer-readable storage medium which stores a program for executing a data processing method of extracting watermark information from digital data in which the watermark information is embedded by a method having:

a watermark embedding step of embedding watermark information to be embedded into the digital data; and

a common watermark embedding step of embedding, into the digital data, version information for specifying a version of an embedding scheme used in the watermark embedding step, at high resiliency,

said program comprising:

a common watermark extraction step module for extracting the version information embedded by a common watermark embedding step module;

a specifying step module for specifying, on the basis of the version information extracted by said common watermark extraction step module, a watermark embedding technique with which the watermark information is embedded into the digital data;

a selection step module for selecting a watermark extraction technique for extracting watermark information corresponding to the watermark embedding technique specified by said specifying step module; and

a control step module for controlling to extract the watermark information from the digital data using the watermark extraction technique selected by said selection step module.

16. A data processing method comprising:

a detection step of detecting time information related to image data having additional information embedded as a digital watermark; and

a change step of changing an embedding scheme for the additional information as the digital mark, from an invisible watermarking scheme to a visible watermarking scheme, on the basis of the time information detected at said detection step.

17. A data processing method comprising:

a detection step of detecting time information related to the image data having additional information embedded as a digital watermark; and

a change step of changing an embedding scheme for the additional information as the digital mark, from a first visible watermarking scheme to a second visible watermarking scheme, on the basis of the time information detected at said detection step.

18. A computer-readable storage medium which stores a program for executing a data processing method of embedding a digital watermark into digital data, said program comprising:

a detection step module for detecting time information related to the image data having additional information embedded as a digital watermark; and

a change step module for changing an embedding scheme for the additional information as the digital mark, from an invisible watermarking scheme to a visible watermarking scheme, on the basis of the time information detected by said detection step module.

19. A computer-readable storage medium which stores a program for executing a data processing method of embedding a digital watermark into digital data, said program comprising:

a detection step module for detecting time information related to image data having additional information embedded as a digital watermark; and

a change step module for changing an embedding scheme for the additional information as the digital mark, from a first visible watermarking scheme to a second visible watermarking scheme, on the basis of the time information detected by said detection step module.

20. A computer-readable storage medium which stores a program for extracting watermark information from digital data in which the watermark information is embedded by an apparatus having

watermark embedding means for embedding watermark information to be embedded into the digital data; and

common watermark embedding means for embedding, into the digital data, version information for specifying a version of an embedding scheme used by said watermark embedding means, at high resiliency, said program comprising:

a common watermark extraction step module for extracting the version information embedded by the common watermark embedding means;

a specifying step module for specifying, on the basis of the version information extracted by said common watermark extraction step module, the version of the embedding scheme with which the watermark information is embedded into the digital data;

a selection step module for selecting watermark extraction step module capable of extracting watermark information corresponding to the version specified by said specifying step module; and

a control step module for controlling to extract the watermark information from the digital data using said watermark extraction step module selected by said selection step module.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,707,465 B2
DATED : March 16, 2004
INVENTOR(S) : Takeshi Yamazaki et al.

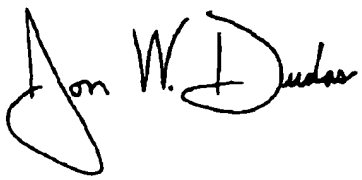


It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [75], Inventors, "Tokyo" should read -- Kanagawa -- (both instances)
Item [56], **References Cited**, OTHER PUBLICATIONS, "H. Ishizuka et al." reference, "A Digital Watermark technique" should read -- A Digital Watermark Technique --; "Transfor" should read -- Transform --; and "H. INour et al." reference, "INour" should read -- Inoue --.

Signed and Sealed this

Tenth Day of August, 2004



JON W. DUDAS
*Acting Director of the United States Patent and Trademark Office*